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User's Manual for Premining Planning of Eastern Surface Coal Mining. Volume 6 Mine Land Planning

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16. ABSTRACT

This volume is the sixth in a series of six reports designed to provide the surface coal mining industry and its regulators with a comprehensive review of the best available methods for extracting coal while protecting the environment. The six-volume report examines the surface mining of coal in the Eastern United States and sets guidelines for developing, evaluating, and selecting mining and reclamation plans that will be the least detrimental to the environment.

The principal objective of the report is to examine and evaluate the various factors and considerations associated with considerations into a comprehensive guide for use by mine planners and managers. The report has three major sections. The first of these is a brief introduction to the overall mine land planning process. The second examines the major cultural and natural factors that determine land use suitability. The third provides a practical review of the important planning considerations and requirements associated with the major land use types.

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USER'S MANUAL FOR PREMINING PLANNING OF EASTERN SURFACE COAL MINING
Volume 6: Mine Land Planning

by

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EPA Grant No. R803882

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FOREWORD

When energy and material resources are extracted, processed, converted, and used, the related pollutional impacts on our environment and even on our health often require that new and increasingly more efficient pollution control methods be used. The Industrial Environmental Research Laboratory-Cincinnati (IERL-Ci) assists in developing and demonstrating new and improved methodologies that will meet these needs both efficiently and economically.

This volume is the last in a series of six reports designed to provide the surface coal mining industry and its regulators with a comprehensive review of the best available methods for extracting this valuable mineral resource while protecting the fragile environment. The specific objective is to examine and evaluate the various factors associated with the postmining uses of the mine site and to organize these factors into a comprehensive guide for use by the mining industry and its regulators.

David G. Stephan
Director
Industrial Environmental Research Laboratory
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ABSTRACT

This manual studies the surface mining of coal in the Eastern United States and sets out guidelines for developing, evaluating, and selecting mining and reclamation plans that will be the least detrimental to the environment. The study considers only the geological and hydrological settings before mining as the basic inputs to premining planning, and develops guidelines for assessing alternatives in the areas of surface mine engineering, water management, and land use planning.

The recommended methods, techniques, and alternatives for selecting and designing mining systems are based on a review and critical evaluation of the methods reported in the literature and applied in the field. They are presented in a series of six reports, which together comprise the User's Manual for Premining Planning of Eastern Surface Coal Mining.

This report, the sixth and final report in this series, addresses the subject of mine land planning. The principal objective of the report is to examine and evaluate the various factors and considerations associated with the postmining uses of the mine site and to organize these factors and considerations into a comprehensive guide for use by mine planners and managers. The report has three major sections. The first of these is a brief introduction to the overall mine land planning process. The second examines the major cultural and natural factors that determine land use suitability. And the third provides a practical review of the important planning considerations and requirements associated with the major land use types.

This report was submitted in fulfillment of Grant No. R803882 by the Department of Mineral Engineering of The Pennsylvania State University under the sponsorship of the U.S. Environmental Protection Agency. This report covers the period July 1, 1975, to May 30, 1978, and work was completed as of August 1, 1981.

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LIST OF ABBREVIATIONS

AASHO	-- American Association of State Highway Officials
AGFC	-- Arkansas Game and Fish Commission
AWRBIC	-- Arkansas-White-Red Basins Inter-Agency Committee
BSFW	-- Bureau of Sports Fisheries and Wildlife
CEQ	-- Council on Environmental Quality
cm	-- centimeters
CZM	-- Coastal Zone Management
DNR	-- Department of Natural Resources
DOT	-- Department of Transportation
FPC	-- Federal Power Commission
ft	-- feet
ft^2	-- square feet
FWS	-- Fish and Wildlife Service
ha	-- hectares
in.	-- inches
KWRB	-- Kansas Water Resources Board
m	-- meters
m^2	-- square meters
MBIC	-- Missouri Basin Interagency Committee
NPDES	-- National Pollution Discharge Elimination System
NRPA	-- National Recreation and Parks Association
NRPB	-- National Resources Planning Board
SCS	-- Soil Conservation Service
SI	-- Smithsonian Institution
SME	-- Society of Mining Engineers of The American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc.
UMRBCC	-- Upper Mississippi River Basin Coordinating Committee
USAED	-- U. S. Army Engineer Division
USBM	-- U. S. Bureau of Mines
USDA	-- U. S. Department of Agriculture
USGPO	-- U. S. Government Printing Office
USGS	-- U. S. Geological Survey

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The materials contained in this report were prepared as a joint effort of the Department of Mineral Engineering and the Department of Geography of the College of Earth and Mineral Sciences of The Pennsylvania State University. Overall management for the project was provided by Dr. R. V. Ramani of the Department of Mineral Engineering who was responsible for formulating the concept and framework for this report. Initial guidance and research efforts in the preparation of this report were provided jointly by Dr. L. W. Saperstein, assisted by Mr. J. Riddle of the Department of Mineral Engineering, and by Dr. C. G. Knight, assisted by Ms. P. Duhaime of the Department of Geography. The final structure and contents of the report were formulated by Mr. M. Clar of the Department of Mineral Engineering, who was the project coordinator for the research effort.

Although the topic of mine land planning is a relatively new concept for surface mining operations, the concepts from which it is derived, namely comprehensive land use or community planning and environmental site planning, are reasonably well established and documented for urban and rural land uses. Consequently, the major thrust of the work contained here consisted of reviewing and evaluating these older concepts and adapting any applicable elements to the planning of surface mine lands. Therefore, many of the topics developed in this report are simply extensions of these ideas to surface mining operations.

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PROJECT STAFF

The materials contained in the manual were prepared by an interdepartmental and interdisciplinary group of the College of Earth and Mineral Sciences of The Pennsylvania State University. Overall management for the project was provided by the Department of Mineral Engineering. The project staff was comprised of the following personnel:

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SECTION 1

INTRODUCTION

OVERVIEW

This report is the last in a series of six reports that together make up the User's Manual for Premining Planning of Eastern Surface Coal Mining. The topic of this volume is mine land planning, which is the process whereby (a) a potential mine site is evaluated to determine its suitability for supporting a variety of land uses and (b) a land use is ultimately selected, designed, and implemented to be compatible with both the site environment and overall community development objectives.

Selection of a suitable postmining land use must satisfy two general criteria. First, the land use must be compatible with the total site environment, and second, the land use must also be compatible with overall community development objectives. Consequently, mine land planning requires consideration of two distinct yet complementary planning processes known as (1) environmental site planning, and (2) land use or comprehensive community planning. Figure 1 details these two levels of planning. This report concerns itself primarily with the application of environmental site planning methods as a process for determining the land use suitability of the mine site. It is recognized, however, that the final determination of which land use to adopt for a given site is not a function of mining companies. Rather, that decision-making authority rests with the community and should be exercised by its designated land use authority or planning board.

BACKGROUND

The mining process has been defined as the act, process, or work of extracting minerals or coal from their natural environment and transporting them to the point of processing or use (Given, 1973). Early surface mining ventures consisted of two major phases--namely, exploration and extraction. Exploration was performed to discover, delineate, and prove the orebody. Extraction operations consisted simply of removing the surface, vegetation, topsoil, rock, and other strata lying above the mineral or fuel deposits and loading the deposit for transport to the point of processing or use. The legacy of this outdated approach is still evident in the older mining districts in the scarred landscapes and polluted streams. Unfortunately, a large proportion of the American public still carries this obsolete image of surface mining and consequently holds a very negative view of the industry.

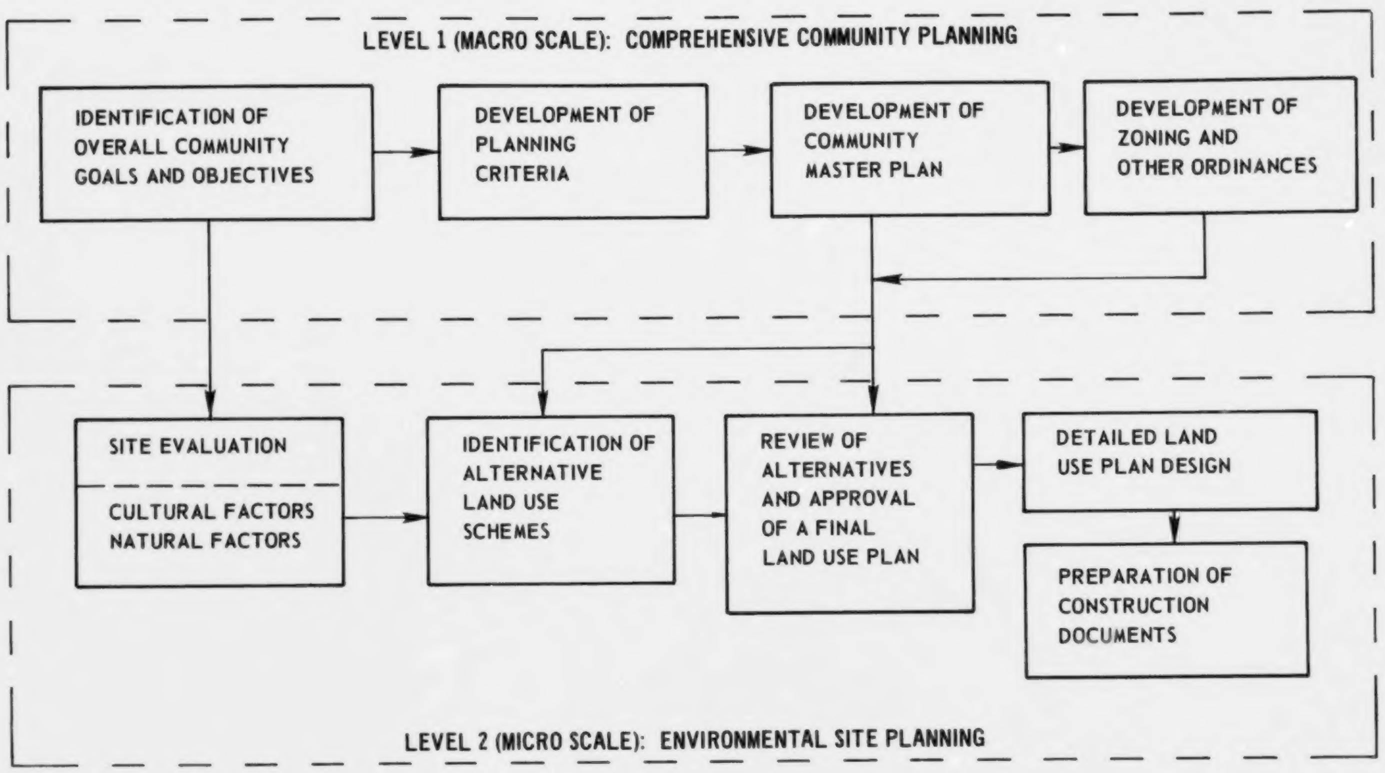
LEVEL 1 (MACRO SCALE): COMPREHENSIVE COMMUNITY PLANNING
IDENTIFICATION OF OVERALL COMMUNITY GOALS AND OBJECTIVES
DEVELOPMENT OF PLANNING CRITERIA
DEVELOPMENT OF COMMUNITY MASTER PLAN
DEVELOPMENT OF ZONING AND OTHER ORDINANCES
SITE EVALUATION
CULTURAL FACTORS
NATURAL FACTORS
IDENTIFICATION OF ALTERNATIVE LAND USE SCHEMES
REVIEW OF ALTERNATIVES AND APPROVAL OF A FINAL LAND USE PLAN
DETAILED LAND USE PLAN DESIGN
PREPARATION OF CONSTRUCTION DOCUMENTS
LEVEL 2 (MICRO SCALE): ENVIRONMENTAL SITE PLANNING

Figure 1. Levels of planning involved in the mine land planning process.

Current surface mining operations are considerably different from the early ventures because of an added dimension, a third phase termed reclamation. Reclamation of surface mined lands has two basic functions: (1) the elimination or abatement of undesirable environmental conditions, and (2) the restoration of the mined land to its former or more productive uses.

A brief history of the development of reclamation efforts on surface mined lands can be found in the USGS Circular 731 (Imhoff et al., 1976). It is interesting to note that the reclamation of surface mined lands in the United States began in the Midwest in the 1920's as a voluntary experimental program initiated by coal companies attempting to establish, at minimum costs, quick-growing forests on ungraded spoil heaps. The first state mined-land reclamation law was enacted in West Virginia in 1939. Other states quickly followed suit. As a result of these laws, rules were promulgated requiring revegetation and, in some cases, reduction of spoil pile slopes to convert strip mined land to a land-cover type that would be of economic value and would reduce erosion.

Since these early efforts, reclamation laws and regulations have continued to grow both in number and scope. Requirements for soil conservation and water quality control were added, partly as a consequence of the increasing involvement of Federal and State agencies in pollution control. In time, provisions were included to require consideration and development of post-mining land uses.

This trend in increased regulation of the environmental aspects of surface coal mining operations culminated in the enactment by the 95th Congress of Public Law 95-87, the Surface Mine Control and Reclamation Act of 1977. This act, which establishes minimum levels of performance and control on a nationwide basis, goes well beyond the levels of environmental regulation previously required by most states in numerous aspects of permitting and reclaiming surface mining operations. More importantly, however, it provides a shift in mine planning philosophy. Early reclamation efforts were developed as an afterthought, or as a secondary aspect, of mining operations, the primary emphasis being placed on production. The new law reverses these roles by requiring that reclamation and environmental protection measures be demonstrated as feasible before issuance of a coal mining permit.

OBJECTIVES

As a consequence of this increasing level of involvement and regulation by governmental agencies (particularly Public Law 95-87), surface coal mine planners and managers will be required to consider many new topics in the mine planning process. Foremost among these new considerations will be how to integrate the concept of postmining land use into the mine planning process. The mine planner will have to rapidly adapt and gain working knowledge of many new terms and ideas and their implications. Some of these include:

1. Land capability,
2. Alternative land uses,
3. Prime agricultural lands,

4. Soil productivity,
5. Existing and higher land uses,
6. Comprehensive land use planning, and
7. Environmental site planning.

Although the actual work called for in the execution of these concepts will require the services of professionals trained in these respective fields, the mine manager or planner needs an overall awareness of the work that must be done as well as the knowledge of how to structure this technical input into the mine planning process. Therefore, the principal objective of this report is to examine and evaluate the various factors and considerations involved in mine land planning and to organize these factors and considerations into a comprehensive guide for use by mine planners and managers.

SCOPE AND USE OF REPORT

This report can be subdivided into three major areas of emphasis. Sections 2 and 3 discuss and provide an overview of mine and planning concepts. Section 2 provides a brief introduction to the overall mine land planning process that includes a statement of the goals and objectives of mine land planning as well as a description of the principal structural components of the process. A comprehensive review of one of these structural components, the identification of the regulatory constraints associated with mine land planning, is provided in Section 3.

The second major area of discussion is contained in Sections 4 through 7. This phase of the report examines the major cultural and natural factors that determine land use suitability. An evaluation of these factors for a proposed mine site is the basis of the environmental site planning process. This process or methodology can be successfully utilized to perform the following functions:

1. Identify all existing resources at the site,
2. Evaluate potential postmining land uses,
3. Select the most suitable land use, and
4. Design an integrated mining and reclamation plan.

Section 4 addresses the principal cultural factors that determine the economic value of the site. Factors grouped under the term geographic are a combination of spatial, economic, and market factors that include location, accessibility, size and shape of the site, surrounding land uses, and intensity of use.

Section 5 presents a discussion of some important climatic factors. These include temperature, humidity, precipitation, solar radiation, and wind.

Section 6 examines the influence of geomorphic factors on land use suitability. These include topography, slope, drainage, altitude, and exposure.

The importance of soil factors in determining land use suitability is discussed in Section 7. This section is also intended to provide a brief summary of important soil concepts to the mine planner. This section provides a discussion of the soil profile, a review of popular terms for soil layers, an inventory and description of major soil types, and a classification system for mine spoils. In addition to the agricultural uses of the soil, a discussion of the engineering uses of soils is included. Finally, a brief discussion of the county soil survey report and its many uses is provided. This section concludes the second major phase of discussion.

The third and final major area of discussion, contained in Sections 8 through 11, is intended to provide a review of planning considerations and requirements associated with the major land use types. The land use types are grouped and discussed in accordance with the frequency with which they are encountered in reclamation operations. Consequently, forestry and wildlife uses are grouped together and discussed first in Section 8. Agricultural land uses are discussed next in Section 9. This is followed by a discussion of recreational land use in Section 10. Finally, residential and selected institutional land uses are grouped together under the heading of community development in Section 11, concluding this third major area of discussion.

SECTION 2

THE MINE LAND PLANNING PROCESS

OVERVIEW

Surface coal mining ventures can exhibit a considerable degree of variation in size and complexity of operations. A coal mining operation can consist of developing a small parcel of land ranging from ten to twenty acres in size that uses existing community facilities, or it can consist of a major undertaking of up to several hundred acres that requires the development of an entire community to support the mining operation. Naturally, the level of planning required will tend to reflect the nature and extent of the mining operation. However, regardless of the size and complexity of the venture, there are certain general planning processes that should be adopted as a minimum level of effort.

Mine land planning is the process of evaluating a potential mine location to determine not only the land use capability of the site but also ultimately the selection, design, and implementation of a land use plan that is compatible with both the site environment and the overall community development objectives. The components of this definition provide the structural framework for the mine land planning process (Figure 2).

The materials in this report emphasize the first four phases of this planning process, namely: (1) the identification of regulatory constraints, (2) site evaluation, (3) identification of potential land use alternatives, and (4) evaluation of alternatives and selection of postmining land use(s). The other two phases, the detailed design and the preparation of construction documents, follow naturally from the first four phases, and although some discussion is provided of the major elements of design to be considered for various land use types, a comprehensive discussion of the design elements for each type of land use is beyond the scope of this report. However, where possible, reference materials have been identified to guide the reader to comprehensive publications of these topics. The focus of the report is on what should be evaluated, why it should be evaluated, and how the evaluation can be used to identify and select suitable postmining land uses.

GOALS AND OBJECTIVES OF MINE LAND PLANNING

Mine land planning has two major goals. These are the implementation of postmining land use plans that are (1) compatible with the site environment and (2) compatible with overall community development objectives. The first of these two goals, implementation of postmining land use plans compatible

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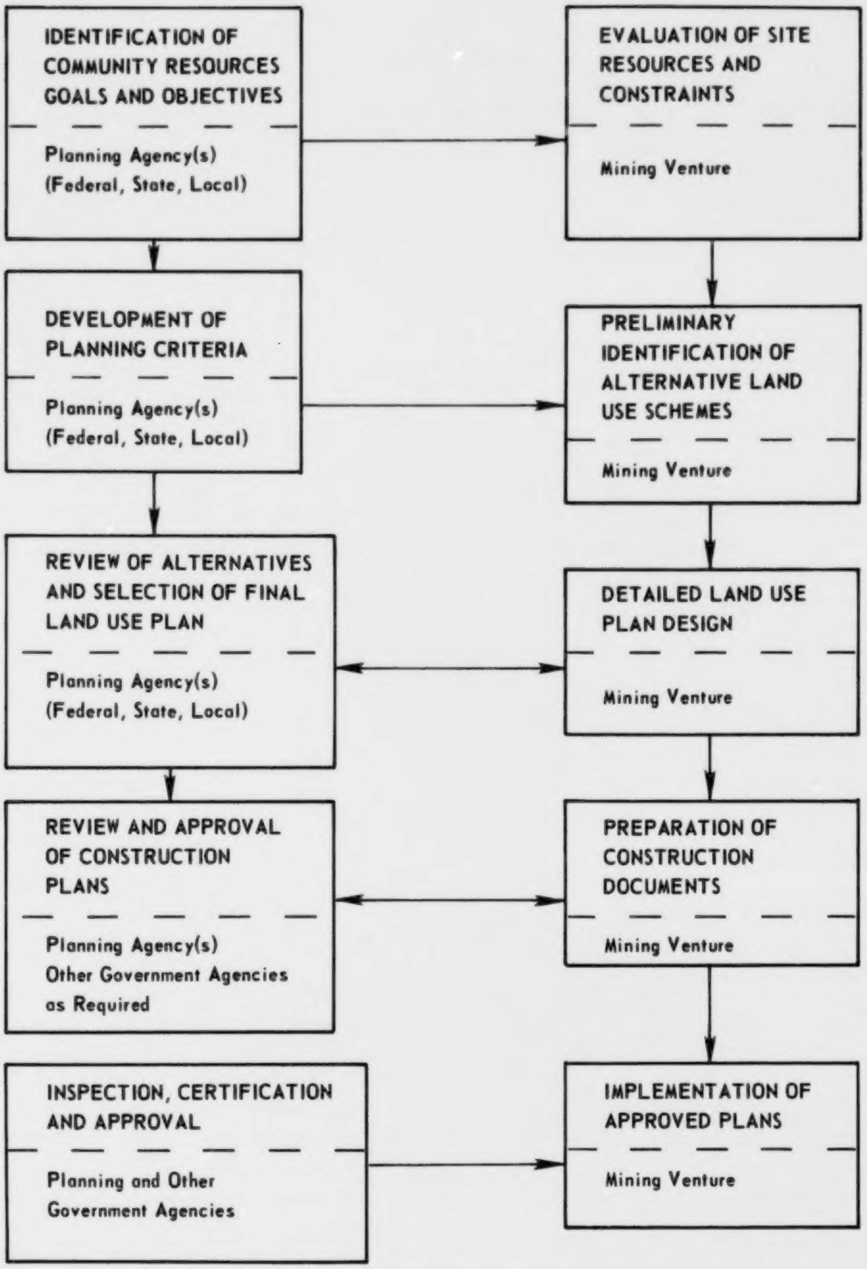
IDENTIFICATION OF COMMUNITY RESOURCES GOALS AND OBJECTIVES
Planning Agency(s) (Federal, State, Local)
EVALUATION OF SITE RESOURCES AND CONSTRAINTS
Mining Venture
DEVELOPMENT OF PLANNING CRITERIA
Planning Agency(s) (Federal, State, Local)
PRELIMINARY IDENTIFICATION OF ALTERNATIVE LAND USE SCHEMES
Mining Venture
REVIEW OF ALTERNATIVES AND SELECTION OF FINAL LAND USE PLAN
Planning Agency(s) (Federal, State, Local)
DETAILED LAND USE PLAN DESIGN
Mining Venture
REVIEW AND APPROVAL OF CONSTRUCTION PLANS
Planning Agency(s) Other Government Agencies as Required
PREPARATION OF CONSTRUCTION DOCUMENTS
Mining Venture
INSPECTION, CERTIFICATION AND APPROVAL
Planning and Other Government Agencies
IMPLEMENTATION OF APPROVED PLANS
Mining Venture

Figure 2. Mine land planning process.

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with the site environment, can be viewed as a microscale planning function that is totally the domain and responsibility of the mining venture. Microscale planning has been well defined and applied in several fields and is commonly referred to as environmental site planning. This report concerns itself primarily with the application of these environmental site planning methods as a process used to determine the land use suitability of the mine site. The intent of this first goal can be translated into two operationally concise objectives:

1. Control of the onsite and offsite effects and environmental impacts of the mining operation on neighboring lands and waters within acceptable limits as defined by the U.S. Environmental Protection Agency and other regulatory agencies, and
2. Restoration of the mined site so that it is capable of supporting a level of activity at least equal to or better than that available before any mining activity.

The second goal of mine land planning, the implementation of land use plans compatible with overall community objectives, can be viewed as part of a macroscale planning function that is the shared domain of the mining venture and the land use planning authority. The land use planning authority generally will be found at the local level to be a county or borough governmental unit but can also be a separate regional board, a state agency, or even a federal agency, such as occurs when mining takes place on public lands. The planning agency plays the lead role in this macroscale planning effort through the use of a planning process referred to as comprehensive land use planning that fosters the development, orderly use, conservation, and protection of natural resources. Where this process has been implemented, a comprehensive land use plan has developed that specifies how present and future improvements and uses of land and other natural resources should be developed. This plan serves as a guide to both public and private development activities.

The role of the mine operator in this macroscale planning effort consists of identification of the guidelines that apply to the mine site and adoption of a postmining land use that conforms with the comprehensive plan. This report does not directly address this macroscale planning process except for those aspects that interface with microscale planning processes previously described. However, the reader interested in this aspect of mine planning can refer to the current efforts of the USGS to develop an integrated mined-area reclamation and land use planning process (Imhoff et al., 1977). Mine operators also should keep abreast of these efforts since the implementation of these processes is likely to result in additional regulation of the industry in the near future.

The intent of this second goal of mine land planning has been translated into four operationally concise objectives to be implemented into the development of a comprehensive land use plan in the coal regions (Imhoff et al., 1977). These objectives are:

1. Protection and conservation of mineral resources,
2. Promotion of economic growth and local employment,

3. Provision for contemporaneous, integrated, or simultaneous extraction and reclamation operations, and
4. Avoidance of the creation of a sacrifice site with few potential uses after extractive operations are complete.

IDENTIFICATION OF REGULATORY CONSTRAINTS

One of the first tasks in the mine land planning process should be the identification of all statutory laws and regulations that affect surface coal mining operations, with special emphasis being placed on land use controls and regulations. In response to the shortcomings of common law procedures as a tool for resolving disputes related to the impacts of coal mining operations, a variety of statutes and regulations have been developed to control the impacts of surface mining operations. This statutory intervention generally has taken one of two forms. It either has focused directly on mining through promulgation of surface mining laws or has covered mining operations as part of a more general attempt to protect quality, such as the EPA effluent guidelines. This legislation, developed to control surface mining activities, appeared initially at the state level and has since been reinforced by local ordinances in some cases, by interstate compacts in others, and more recently by Federal legislation. A more detailed review of the involvement of regulatory agencies in surface coal mining operations at all levels of government is provided in Section 3. A summary of Federal and state mining and environmental laws that are related to mining operations follows.

Federal and State Mining and Environmental Laws
(Knight and Duhaime, 1977)

Mining Laws
  Federal
    Federal Metal and Nonmetallic Mine Safety Act (1969)
    Federal Coal Mine Health and Safety Act (1969)
    Mining and Minerals Policy Act (1970)
    Surface Mining Control and Reclamation Act (1977)
  State
    Each state in the study area has a surface mining and reclamation act governing the extraction of coal by surface mining methods.

Environmental Laws
  Federal
    Refuse Act (1899)
    Fish and Wildlife Coordination Act (1934)
    Federal Water Pollution Control Act (1948)
    Wilderness Act (1964)
    Appalachian Development Act (1956)
    Solid Waste Disposal Act (1956)
    Water Quality Act (1965)
    National Historic Preservation Act (1966)
    Wild and Scenic Rivers Act (1968)
    National Environmental Policy Act (1969)
    Occupational Safety and Health Act (1970)

- Federal (continued)
  - Clean Air Act (1970) and Amendments (1970)
  - Federal Water Pollution Control Act Amendments (1972)
  - Flood Disaster Prevention Act (1973)
  - Endangered Species Act (1973)
- State
  - Alabama--Air Pollution Control Act
  - Arkansas--Utility Facilities Environmental Protection Act
  - Georgia--Water Quality Control Act
    - Noise pollution statute
    - Vital Areas Council
    - Ground Water Act
  - Illinois--Environmental Protection Act
    - Deferred taxation scheme to preserve agricultural land
  - Indiana--Environmental Protection Act
    - Flood Control Act
    - Preferential taxation to preserve agricultural land and open spaces
    - Ground Water Conservation Act
  - Iowa--Agricultural land assessed at use value
    - Flood Plain Management Act
  - Kansas--None
  - Kentucky--Power Plant Siting Act
    - Water Appropriation Act
    - Water Resources Act
    - Environmental Protection Law
  - Maryland--Scenic Rivers Act
    - Flood Plain Management Act
    - Environmental Protection Act
    - Wilderness Preservation
    - Critical Areas Act
  - Michigan--Administratively promulgated NEPA equivalent (Executive Order 1974-4)
    - Natural Rivers Act
    - Agricultural Land and Open Space Act
  - Missouri--Solid Waste Disposal Act
    - Clean Water Law
    - Environmental Improvement Authorization
    - Air Conservation Law
    - Critical Areas Designation
  - Nebraska--Environmental Protection Act
  - North Carolina--Environmental Policy Act
    - Land Policy Act
    - Water Use Act
  - Ohio--Watercourse Protection Act
    - Use-Value Assessment of Agricultural Land
  - Oklahoma--Water Pollution Control Act
    - Ground Water Act
  - Pennsylvania--Land and Water Development Act
    - Clean Streams Act
    - Water Obstruction Act
    - Solid Waste Management Act

Pennsylvania--Air Pollution Control Act
South Carolina--None
Tennessee--Stream Pollution Control Act
  Water Quality Control Act
  Scenic Rivers Act
Virginia--Environmental Protection Act
  Water Control Law and Amendments
  Air Pollution Control Law
  Clean Air Act
West Virginia--Water Pollution Control Act
  Natural Streams Preservation Act
  Dam Control Act
  Air Pollution Control Law
  Coal Refuse Disposal Control Act
  Critical Areas Designation
  Regional Planning and Development Act
  Natural Resources Act

SITE EVALUATION

One of the major areas of emphasis of this report concerns itself with the application of environmental site planning methods as a process for determining the land use capability of the mine site. At the very core of this process is a comprehensive and detailed evaluation of the various site factors. These site factors are generally grouped under two broad categories--namely, cultural factors and natural factors.

The evaluation of these site factors for a mine site must be approached in a somewhat different manner than that normally used in site planning. The reason for this difference in approach stems from the relative lack of flexibility in siting coal mining operations and on the nature of the mining process itself. In general, when siting a particular land use activity, several potential sites may be considered and an optimization method may be used to select the most desirable site. In addition, the evaluation of many of the natural factors is approached with the objective of creating the least amount of disturbance of the site, particularly with respect to cut-and-fill grading operations. Except for the areas occupied by necessary utilities and structures, the subsurface environment is left essentially unchanged.

Mining sites differ from the above scenario, however, in several ways. First, there seldom is a choice of several potential sites. Surface coal mines must be sited where coal deposits are present and where mineral and surface rights can be acquired. Second, the surface mining process involves a complete reconstruction of the subsurface environment above the coal bed. Consequently, when evaluating the existing site factors, the mine planner also must consider how these factors will be modified by the mining operation and what potential exists to modify and possibly improve the existing site conditions.

Cultural Factors

The cultural factors consist of that group of factors that relate man's activities to the use of the land and its resources. These factors encompass a combination of spatial, economic, and market considerations. The influence of the cultural factors in determining the suitability of the site to support various land use types is discussed in Section 4 under the heading Geographic Factors. The factors that are discussed include:

1. Location,
2. Accessibility (linkages),
3. Size and shape factors,
4. Surrounding land uses, and
5. Intensity of use (zoning).

Natural Factors

The discussion of natural factors in this report has been organized under three broad headings, namely (1) climatic factors, (2) geomorphic factors, and (3) soil factors. The elements considered under each grouping are listed below. Since volumes 3 and 4 of this series of reports address the geologic and hydrologic considerations associated with surface mining operations, these topics are not treated in any great detail in this report. Rather, this report focuses primarily on related and complimentary considerations to provide a full spectrum of topics to be considered in the mine planning process.

Natural Site Factors

Geomorphic Factors	Climatic Factors	Soil Factors
Topography	Rainfall	Soil profile
Slope	Temperature	texture
Drainage	Humidity	structure
Exposure	Solar radiation	organic matter content
Altitude	Wind	moisture
		permeability
		pH
		depth to bed rock
		color
		Engineering properties
		shrink-swell potential
		wetness
		erodibility
		flood hazard
		slope
		bearing capacity
		corrosion

The natural factors can be grouped further under the headings of active and passive forces as listed below. The active forces, which include all the climatic factors, are fixed by geographic location and are generally beyond the control of man. Thus mine planners must be cognizant of these forces of

Active Forces	Passive Forces
Rainfall	Topography
Temperature	Slope
Humidity	Drainage
Solar radiation	Soil profile
Wind	Agricultural properties
Exposure	Engineering properties
Altitude	

nature and wisely schedule the operations to take advantage of the seasonal (and/or finer divisions) fluctuation exhibited by these elements.

In contrast, the passive forces, which include all the soil factors, are elements that can be affected and modified by the surface mining process--and thus some degree of control at best is available. In the reconstruction of a surface mine environment, more opportunity exists for reshaping these elements to optimize their desirable characteristics than in any other industrial enterprise. The challenge clearly consists of using the wealth of knowledge developed by scientists over the years from a multitude of investigations into the natural sciences and applying them to optimize the utility of the land in the postmining stages.

IDENTIFICATION OF POTENTIAL LAND USES

Once the pertinent regulatory constraints have been identified and after the site factors have been properly evaluated, one or more land uses will be identified as compatible with both the site environment and the community's development objectives. Though forestry and agriculture still remain the predominant postmining land uses, the inherent potential of mined lands to be integrated into the community development process is increasingly recognized. Alternative uses of reclaimed surface mines reported in West Virginia illustrate a trend (Table 1).

The fact that land use decisions significantly affect the quality of life both in the short and long run is now widely accepted by citizens and elected officials. Increased awareness of this has led many jurisdictions--urban and rural, large and small--to demand improved ways of evaluating the impacts of proposed and existing land developments. A recent effort to develop a methodology for that purpose was conducted by the Urban Institute in which they identified the major community objectives for regulating land development (Schaenman, 1976). These objectives are presented below. In addition, they

Community Objectives for Regulating Land Development
(Schaenman, 1976)

I. Local economy: To keep the local government fiscally solvent without excessive taxes; to maintain a high level of stable employment and to reduce unemployment and under-employment in the community; to maintain prosperity; and to enable citizens in the community to achieve levels of personal income and wealth consistent with a decent standard of living.

TABLE 1. ALTERNATIVE USES OF RECLAIMED SURFACE MINES IN WEST VIRGINIA (Greene, 1976)

I. Commercial		Location
A. Under Construction		
1.	Motel (Holiday Inn) & Industrial park	Weston
2.	Industrial park	Bridgeport
3.	Airport	Williamson
4.	Airport	Logan
5.	Trailer park	Bethany
6.	Sanitary landfill	Logan
7.	Housing development	Summersville
B. Completed		
1.	Harry Greene Chevrolet	Clarksburg
2.	Drive-in theater	Clarksburg
3.	Hill's Plaza shopping center	Bridgeport
4.	Holiday Inn complex	Bridgeport
5.	Heck's shopping center	Bridgeport
6.	Mr. Kleen automatic car wash	Fairmont
7.	Middletown Mall shop center	Fairmont
8.	Murphy Mart - Kroger shopping center	Fairmont
9.	Steel Research Center	Weirton
10.	Department store	Weirton
11.	Shopping plaza	Weirton
12.	Monongahela Power Company office	Weirton
13.	Airport	Weirton
14.	Grant City shopping plaza	Weirton
15.	Alfalfa Pellet plant	Weirton
16.	Explosive blending plant (Mt. State Rotary Bit)	Weirton
17.	Deep mining complex	Bull Creek
18.	Deep mining complex	Phillipi
19.	Deep mining complex	Upshur County
20.	Coal preparation plant	Kayford
21.	Sawmill	Walkersville
22.	Sawmill	Preston County
23.	Farm	Weirton
24.	Farm	Lumberport
25.	Cannelton Farms	Ward
26.	Apple orchard	Buffalo
27.	Apple orchard	Bradshaw
28.	Dairy farm	Masontown
29.	Sawmill	Grafton
30.	Natural gas pumping station	Harrison County

(continued)

TABLE 1. (continued)

		Location
II.	Housing	
1.	Planned community (10,000)	Ward
2.	Residential developments	Beckley
3.	Residential developments (Weirton Heights)	Weirton
4.	Residential developments (Logan Court)	Bethany
5.	Residential developments (with private airfield)	Corrine
6.	Residential developments	Kingwood
7.	Residential developments	Peach Creek
8.	Residential developments (Rush Creek)	Kanawha County
9.	Residential developments (Suan Terr)	Clarksburg
10.	Private home	Dola
11.	Mobile home park	Wellsburg
12.	Mobile home park	Clarksburg
13.	Mobile home park	Buckhannon
14.	Mobile home park	Osage
III.	Public Facilities	
1.	Department of Public Safety (District office & barracks)	Weirton
2.	DNR district offices	Fairmont
3.	Community hospital	Wheeling
4.	Medical center	Weirton
5.	County airport & complex	Logan
6.	Community high school	Weirton
7.	Consolidated high school & vocational/ athletic complex	Welch
8.	Consolidated high school	Coal City
9.	Churches: Protestant	Beckley
	St. Joseph's Catholic	Weirton
	St. Thomas Episcopal	Weirton
	St. Nicholas Orthodox	Weirton
IV.	Recreational (public and private)	
1.	Reclamation for recreation Blackwater Falls State Park	Davis
2.	Fur, Fin & Feather Hunting/Fishing Club	Kingwood
3.	Private hunting/fishing clubs	Preston County
4.	Natatorium	Bethany College
5.	Tennis courts	Bethany College
6.	Little League fields	Clarksburg
7.	Little League fields	Weirton
8.	Wadcutters Pistol/Rifle Range	Summersville
9.	Pistol/rifle range	Preston County

(continued)

TABLE 1. (continued)

V. Miscellaneous	Location
1. Power plant flyash disposal	Mt. Storm
2. Power plant flyash disposal	Morgantown
3. Sanitary landfill	Kingwood
4. Sanitary landfill	Bruceton Mills
5. Sanitary landfill	Elkins
6. Sanitary landfill	Buckhannon
7. Sanitary landfill	Weston
8. Sanitary landfill	Rainelle
9. Sanitary landfill	Fairmont
10. Sanitary landfill	Wellsburg
11. Sanitary landfill	Follansbee
12. Sanitary landfill	Weirton
13. Sanitary landfill	Walkersville
14. Sanitary landfill	Boone County
15. Sanitary landfill	Fayette County
16. Mt. Top Public Service District water supply	Mt. Storm
17. Water tank (housing)	Harrison County

II. Natural environment: To minimize pollution, protect wildlife and ecologically important features, preserve the natural environment, and conserve scarce resources.

III. Aesthetic and cultural values: To protect and improve the physical and cultural attractiveness of the community.

IV. Public and private services:
- Health and safety: To minimize illness, injury, premature death rates, and property loss or damage.
- Recreation: To provide a variety of accessible and enjoyable recreational facilities and programs in the community.
- Education: To provide quality education at all levels for all people in the community; to provide as diverse educational experiences as the community requires; and to assure the convenience and pleasantness of attending school.
- Local transportation: To provide access to an adequate choice of community services, facilities, and employment in a safe, quick, and convenient manner; and to move goods efficiently.
- Shopping. To promote the adequacy, variety, convenience and pleasantness of shopping for people in the community.

V. Housing and social conditions:
- Housing: To increase the opportunity for all citizens to obtain satisfactory housing at prices they can afford.
- Social concerns and community morale: To promote friendliness, psychological well-being, and good community morale while protecting individuals' privacy and ability to regulate their interpersonal contacts.
- Fairness to all groups: To apply each objective with equity to all within the community.

(This set of objectives is illustrative. Each community should determine goals consistent with the desires and values of its citizens. The order of the objectives implies no ranking of priorities.)

developed an illustrative set of suggested impact measures corresponding to the community objectives. This set of suggested impact measures can be used as a guide for communities interested in developing their own set of measures. These impact measures also can be used as a checklist for mining companies to evaluate the potential impact on the community of the proposed land use.

Site considerations for a number of land uses are provided in this report (Sections 8 through 11). The land uses discussed include the following:

1. Forestry and wildlife,
2. Agricultural,
3. Recreational,
4. Residential, and
5. Institutional.

Commercial and industrial land uses are not specifically addressed though it is recognized that these uses are important to the economic growth of the predominantly rural areas that constitute the majority of the coal regions and, consequently, are becoming more frequent. However, the specific requirements for these types of land uses are too detailed for the scope of this report. The more general requirements, particularly with respect to the natural factors, are in many respects similar to the requirements discussed under considerations for community development.

This report focuses primarily on the influence exerted by the cultural and natural site factors on the suitability of the site for a particular type of land use. The discussion is directed to the more general case where no comprehensive land use plan exists for the community in which the mining operation is to be located. If a plan does exist, the mine operator will have the option of accepting and conforming to the designated land use. On the other hand, if he feels that a different land use is justified, he can appeal to the planning or zoning board for a zoning change.

SECTION 3

IDENTIFICATION OF REGULATORY CONSTRAINTS

OVERVIEW

Though land use regulation is generally recognized as a predominant function of local government, many areas of shared responsibility exist at all levels of government. This section presents a review of the level of involvement in the land use planning process at the Federal, state, and local level. The identification of applicable laws and regulations governing the use of mine lands is an important and necessary phase of the mine land planning process.

FEDERAL REGULATIONS

A number of agencies of the Federal government are involved in various aspects of surface mining operations. Table 2 summarizes the extent of involvement of these agencies in the mining process. In addition, the possibility exists that a national land use planning and policy process may be adopted in the near future.

Recent attempts in the U.S. Congress to pass legislation that would establish a national land use planning and policy process has stirred up an intense debate over the role that the Federal government should play in comprehensive land use planning. The land use debate thus far has stimulated many difficult questions concerning the effect of comprehensive land use planning on jobs, housing construction, tax policy, energy development, and the local and national economies. One of the major issues in the debate is not whether land use controls are required but where the authority for this control should rest.

The most direct involvement in the mine land planning process to date by a Federal agency has been mandated by the 95th Congress with the enactment of Public Law 95-87, the Surface Mining Control and Reclamation Act of 1977. This act, which established minimum levels of regulation and control on a nationwide basis, goes well beyond the levels of environmental regulation previously required by most states in numerous aspects of permitting and reclaiming surface mining operations. One notable area of increased control required by the new law is found in the requirements for evaluating and planning postmining uses of the mine site.

Before the enactment of the new law, most states required only that mined lands be rehabilitated through a combination of backfilling, regrading,

TABLE 2. SUMMARY OF INVOLVEMENT OF FEDERAL GOVERNMENT AGENCIES IN SURFACE COAL MINING OPERATIONS

Agency	Functions
1. OSM - Office of Surface Mining	Responsible for overall administration of programs for controlling surface coal mining operations.
2. BLM - Bureau of Land Management	Conducts competitive coal lease sales on the public domain and acquired lands, including lands administered by the U.S. Forest Service and lands that compose the Wildlife Refuge System. Issues preference right leases when permittee qualifies.
3. USGS - U.S. Geological Survey	Evaluates data and provides advice to BLM regarding areas proposed for leasing; approves mining plans and supervises operations conducted under BLM coal leases. Systematically collects and publishes geologic data necessary for mine planning, including base topographic maps, geological maps, water resources data, etc. Publishes information in methods and procedures for systematic collection and analysis of geologic data.
4. U.S. EPA - U. S. Environmental Protection Agency	Primarily concerned with protection of air and water resources. Issues effluent standards for coal industry. Issues water discharge (NPDES) permits (and enforces its stipulations) for states where a state program has not been approved. Provides technical assistance by conducting mining related research programs and issues manuals of practice for pollution control during surface mining.
5. USFS - U.S. Forest Service	Regulates access roads that lead across U.S. Forest Service lands to areas leased for coal production; reviews leasing actions proposed by BLM and recommends stipulations to be included in such leases. Coal mining operations on leased U.S. Forest Service lands are regulated by the USGS. Forest Service public domain lands can be leased without U.S. Forest Service concurrence. Conducts research programs on effects of surface coal mining operation with particular emphasis on revegetation and wildlife.

(continued)

TABLE 2. (continued)

Agency	Functions
6. BSFW - Bureau of Sports Fisheries and Wildlife	Provides advice and assistance regarding actions proposed by BLM to lease coal and recommends stipulations for inclusion in such leases.
7. MSHA - Mining Safety and Health Administration	Promulgates and enforces worker health and safety regulations in all coal mines. Requires submission and approval of a ground control plan before a surface mining permit is issued. Sets training and educational requirements for certification of mining personnel. Conducts monitoring and enforcement programs on surface mining operations.
8. USBM - U.S. Bureau of Mines	Provides technical assistance by systematically collecting and publishing statistical data for the coal mining industry. Conducts research programs and issues technical reports on all aspects of coal mining operations.
9. COE - U.S. Corps of Engineers	May be involved in the permit review and monitoring and enforcement functions if the mine operation involves any aspects related to navigable waters (e.g., construction of bridges over navigable waters, etc.). Reviews U.S.EPA discharge permits to determine impact of permitted activity upon navigation.
10. OSHA - Occupational Safety and Health Administration	Establishes and enforces worker health and safety regulations in areas not regulated by other Federal agencies, or by states under plans approved by OSHA.
11. USCG - U.S. Coast Guard	Issues permits for railroad bridges across navigable waters where required.
12. ICC - Interstate Commerce Commission	Issues railroad service extension permits where required.
13. DOE - Department of Energy	Provides technical assistance through research programs.

(continued)

TABLE 2. (continued)

Agency	Functions
14. SCS - Soil Conservation Service	Provides technical assistance primarily through the functions of its local officers and plant research centers related to reclamation of surface mines.
15. FCC - Federal Communications Commission	Issues permit to operate microwave (2-way radio) equipment.

topsoiling, and revegetation, designed to insure no substantial environmental degradation. The new law, however, declares this approach to be inadequate, based in part on its findings as stated in 91 STAT. 447, section 101, paragraph (c):

> Many surface mining operations result in disturbance of surface areas that burden and adversely affect commerce and the public welfare by destroying or diminishing the utility of land for commercial, industrial, residential, recreational, agricultural, and forestry purposes, by causing erosion and landslides, by contributing to floods, by polluting the water, by destroying fish and wildlife habitats, by impairing natural beauty, by damaging the property of citizens, by creating hazards dangerous to life and property by degrading the quality of life in local communities, and by counteracting governmental programs and efforts to conserve soil, water and other natural resources.

To counteract these potentially undesirable consequences of surface coal mining operations, the new law provides a number of requirements dealing with the question of how to achieve suitable postmining land uses through reclamation. One such stipulation is provided in Title IV - Control of the Environmental Impacts of Surface Coal Mining under Section 508, Reclamation Plan Requirements.

Listing of Reclamation Plan Requirements Of Public Law 95-87 (Sec. 508a)

> Each reclamation plan submitted as part of a permit application pursuant to any approved State program or a Federal program under the provisions of this Act shall include, in the degree of detail necessary to demonstrate that reclamation required by the State or Federal program can be accomplished, a statement of:
>
> 1. The identification of the lands subject to surface coal mining operations over the estimated life of those operations and the

size, sequence, and timing of the subareas for which it is anticipated that individual permits for mining will be sought;

2. The condition of the land to be covered by the permit prior to any mining including:
   - a. The uses existing at the time of the application, and if the land has a history of previous mining, the uses which preceded any mining; and
   - b. The capability of the land prior to any mining to support a variety of uses giving consideration to soil and foundation characteristics, topography, and vegetative cover, and, if applicable, a soil survey prepared pursuant to section 507(b)(16); and
   - c. The productivity of the land prior to mining, including appropriate classification as prime farm lands, as well as the average yield of food, fiber, forage, or wood products from such lands obtained under high levels of management;
3. The use which is proposed to be made of the land following reclamation, including a discussion of the utility and capacity of the reclaimed land to support a variety of alternative uses and the relationship of such use to existing land use policies and plans, and the comments of any owner of the surface, State and local governments or agencies thereof which would have to initiate, implement, approve or authorize the proposed use of the land following reclamation;
4. A detailed description of how the proposed postmining land use is to be achieved and the necessary support activities which may be needed to achieve the proposed land use;
5. The engineering techniques proposed to be used in mining and reclamation and a description of the major equipment; a plan for the control of surface water drainage and of water accumulation; a plan, where appropriate, for backfilling, soil stabilization, and compacting, grading, and appropriate revegetation; a plan for soil reconstruction, replacement, and stabilization, pursuant to the performance standards in section 515(b)(7)(A), (B), (C), and (D), for those food, forage, and forest lands identified in sections 515(b)(7); an estimate of the cost per acre of the reclamation, including a statement as to how the permittee plans to comply with each of the requirements set out in section 515;
6. The consideration which has been given to maximize the utilization and conservation of the solid fuel resource being recovered so that reaffecting the land in the future can be minimized;
7. A detailed estimated timetable for the accomplishment of each major step in the reclamation plan;
8. The consideration which has been given to making the surface mining and reclamation operations consistent with surface owner plans, and applicable State and local land use plans and programs;
9. The steps to be taken to comply with applicable air and water quality laws and regulations and any applicable health and safety standards;
10. The consideration which has been given to developing the reclamation plan in a manner consistent with local physical environmental and climatological conditions;

11. All lands, interests in lands, or options on such interests held by the applicant or pending bits on interests in lands by the applicant, which lands are contiguous to the area to be covered by the permit;
12. The results of test boring which the applicant has made at the area to be covered by the permit, or other equivalent information and data in a form satisfactory to the regulatory authority, including the location of subsurface water, and an analysis of the chemical properties including acid forming properties of the mineral and overburden: Provided, That information which pertains only to the analysis of the chemical and physical properties of the coal (excepting information regarding such mineral or elemental content which is potentially toxic in the environment) shall be kept confidential and not made a matter of public record;
13. A detailed description of the measures to be taken during the mining and reclamation process to assure the protection of:
    a. The quality of surface and groundwater systems both on- and off-site, from adverse effects of the mining and reclamation process;
    b. The rights of present users to such water; and
    c. The quantity of surface and groundwater systems, both on- and off-site, from adverse effects of the mining and reclamation process or to provide alternative sources of water where such protection of quantity cannot be assured;
14. Such other requirements as the regulatory authority shall prescribe by regulations. (b) Any information required by this section which is not on public file pursuant to State law shall be held in confidence by the regulatory authority.

The new law also requires the states to establish a state planning process to determine which, if any, land areas of a state are unsuitable for all or certain types of surface coal mining operations. Under this stipulation (i.e., Section 522, Title IV, Public Law 95-87) a state may designate an area as unsuitable for all or certain types of surface coal mining operations if any of the following criteria are encountered:

1. The state regulatory agency determines that reclamation pursuant to the requirements of the Surface Mining Control and Reclamation Act of 1977 is not technologically and economically feasible.
2. Mining operations are incompatible with existing state or local land use plans and programs.
3. Mining operations will affect fragile or historic lands in which such operations could result in significant damage to important historic, cultural, scientific, and aesthetic values and natural systems.
4. Mining operations will affect renewable resource lands (including aquifers and aquifer recharge areas) in which such operations could result in substantial loss or reduction of long-range productivity of water supply or of food and fiber products.
5. Mining operations will affect natural hazard lands (including areas subject to frequent flooding and areas of unstable geology) in which such operations could substantially endanger life and property.

STATE REGULATIONS

Traditionally, the states have asserted land use authority and in turn delegated it to localities. The states have two options regarding their land use powers: (1) They may exercise the power at the state level through some form of administrative agency, or (2) they may delegate the power to local governments. In all 20 of the states within the eastern coal region, the power to plan has been granted to local government bodies, such as cities, towns, and townships. In all but West Virginia and Oklahoma, county governments also possess planning power. Regional planning bodies operate on an advisory basis in all 20 states. Table 3 summarizes the state land use programs in the eastern 20 states.

Tables 4, 5 and 6 provide additional data on the status of state land use programs for most of the states within the study area (Coffin, 1974). Major areas of concern include land use policy, power plant siting, strip mining, local land use controls, and coastal zone management. In addition to these areas of concern many states are taking action in the areas of wetlands management, designation of critical areas and flood plain management. As mentioned before, the states will also have to develop a planning process for designating areas unsuitable for mining operations to comply with the provision of the Surface Mine Control and Reclamation Act of 1977. The involvement of state, regional, and local government agencies in surface coal mining operations is summarized in Table 7.

LOCAL REGULATIONS

Land use regulation is predominantly a function of local government--10,000 separate local governments--each exercising control over the land within its jurisdiction. However, it can be argued that local land use regulation is a myth and that many local governments fail to exercise their powers and that if they do, they back down easily when challenged in the courts by landowners. Another area of expressed concern is the belief that many local governments despair of reaching any reasonable accommodation with landowners and decide to prohibit everything, leaving the issue up to the courts to resolve. It is alleged, furthermore, that many regions court environmental disaster if future land decisions are left to local governments.

Figure 3 outlines the political system of the local planning commission. The formulation of land use plans is clearly a complex undertaking, transcending many local, state, and federal bureaucracies.

Zoning Regulations and Their Uses (Solberg, 1967)

Planning and zoning are closely related, but the two should not be confused. In general, planning embraces zoning, and zoning may not entirely exclude planning. However, they do not cover identical fields of activity.

Zoning has been defined as the regulation--by districts under the police power--of the height, bulk, and use of buildings, the use of land, and the density of population (Bassett, 1936). This definition embraces the four main

TABLE 3. SUMMARY OF STATE LAND USE PROGRAMS IN THE STUDY AREA (Modified from CEQ, 1977)

State	Type of program		Coastal zone management§	Wetlands management#	Powerplant siting∇	Surface mining**	Designation of critical areas‡	Differential assessment laws§§	Floodplain management##	Statewide Shorelands Act∇∇
	Coordinated incremental*	Mandatory local planning†								
Alabama			X		X	A			X	
Arkansas					X	A,B		A		
Georgia	X		X	X		A,B				
Illinois			X		X	A,B		B	X	
Indiana	X		X			A,B		A	X	
Iowa						A,B		A	X	
Kansas						A,B				
Kentucky					X	A,B		B		
Maryland	X		X	X	X	A,B	X	B	X	
Michigan			X			X		C	X	X
Missouri				X	X	X		A	X	
Nebraska		X			X			B	X	
North Carolina	X		X	X		X		B	X	
Ohio			X		X	A		B		
Oklahoma						X		A	X	
Pennsylvania			X	X	X	A	X	B		
South Carolina			X		X	A		B		
Tennessee					X	A,B				
Virginia		X	X	X		A,B		B		
West Virginia						A,B			X	

* State-established mechanism to coordinate state land-use-related problems.

† State requires local governments to establish mechanism for land use planning (e.g., zoning, etc.)

§ State is participating in federally funded program authorized by the Coastal Zone Management Act of 1972.

State has authority to plan or review local plans and the ability to control land use in the wetlands.

∇ State has autority to determine the siting of powerplants and related facilities.

** State has statutory authority to regulate surface mines. (A) State has adopted rules and regulations; (B) State has issued technical guidelines.

‡ State has established rules, or is in the process of establishing rules, regulations, and guidelines for the identification and designation of areas of critical state concern (e.g., environmentally fragile areas, areas of historical significance).

(continued)

TABLE 3. (continued)

§§ State has adopted a tax measure which is designed to give property tax relief to owners of agricultural or open space lands. (A) Preferential Assessment Program: Assessment of eligible land is based upon a selected formula, which is usually use value. (B) Deferred Taxation: Assessment of eligible land is based upon a selected formula, which is usually use value and provides for a sanction, usually the payment of back taxes, if the land is converted to a non-eligible use. (C) Restrictive Agreements: Eligible land is assessed at its use value; there is a requirement that the owner sign a contract, and a sanction, usually the payment of back taxes if the owner violates the terms of the agreement.

State has legislation authorizing the regulation of floodplains.

∇∇ State has legislation authorizing the regulation of shorelands of significant bodies of water.

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TABLE 4. INSTITUTIONAL AND LEGAL LAND USE CONSIDERATIONS IN THE APPALACHIAN REGION (Coffin, 1974)

State	Land use policy		Power plant siting
	Current status	Legislative actions	
Ohio	No statewide land use policy	Statewide policy is some time off but changes in legislature could produce new policy.	1972 law requires ERS, preempts local control and provides one stop permits.
Pennsylvania	No comprehensive state policy	Interagency task force is studying problem for possible legislative action.	No special law
Maryland	Designates critical areas and can assist localities in enforcing these areas	A bill to establish coastal zone management program failed.	1971 law requires long-range planning by utilities and environmental assessment.
West Virginia	No state land use legislation	State has not considered land use legislation.	Public Service Commission regulates various aspects of power plant construction but not land use.
Virginia	No land use policy	Passed resolution opposing Federal land use act and killed all state legislation. Two major bills now being considered involve critical environmental areas and consistent statewide subdivision ordinances.	No special law
Kentucky	No statewide land use policy	1974 bill created a land use planning council which will recommend legislation.	New law requires certification of environmental compatibility which must be approved by Public Service Commission.
Tennessee	No land use policy	Recommendations for land use legislation were made but the bill was defeated.	Most plants under regulation of TVA.
Alabama	No comprehensive state land use policy or plan	Legislature has proposed a bill to establish a study group to develop land use legislation. 1974-CZM Act was passed so state could participate in federal program.	Public Power Commission has some little-used authority over power plant siting.

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TABLE 4. (continued)

State	Strip mining
Ohio	Tough law prevents water pollution. Land must be reclaimed to original state; coal taxed 4¢ per ton.
Pennsylvania	Tough strip mining laws requiring permits and licensing. Reclamation must be almost concurrent and topsoil must be saved. Original contour must be restored when prior slope was under 12°.
Maryland	Require licensing of operator and a reclamation fee of $30/acre. Must restore land to original contour in low angle mining.
West Virginia	1967 law requires annual permits, a $500 fee, a $60/acre reclamation tax, filing a performance bond, and submitting a reclamation plan.
Virginia	1966 law requires 1-year operating permits and posting of performance bonds. Land must be restored to a "stable condition," that can promote productive use. Reclamation and mining must be concurrent.
Kentucky	Spent more money in 1972 on regulating strip mining than any other state. Original contour must be restored and before permit is issued, applicant must have an erosion and silt control plan.
Tennessee	Strong law requiring separate surface mining and water quality permits. Also a reclamation plan and a high performance bond of at least $600/acre on slopes exceeding 15"; land must resemble original contour; reclamation must be concurrent with mining.
Alabama	Law strengthened in 1973. Enforced by State's Attorney General.

(continued)

TABLE 4. (continued)

State	Local land use controls	Coastal zone management
Ohio	All towns, municipalities have zoning power. State in process of creating multiple county regions.	
Pennsylvania	Full planning and zoning controls to municipalities, townships and counties. There are 10 regional agencies with advisory power.	
Maryland	All counties and municipalities have planning and zoning authority. All counties have functioning planning processes and are required to include certain things in their comprehensive plans by the enabling legislation.	None at present.
West Virginia	Though zoning and subdivision enabling legislation exists, only 6 out of 55 counties have zoning ordinances. No flood plain or wetland protection exist.	
Virginia	Local governments have traditional zoning, planning, and subdivision authority.	The CZM Program is just underway and activities will include a public participation and education program, data collection and analysis, wetlands management and a governmental coordinator program. 1972 wetland legislation calls for a permit system of regulation.
Kentucky	Of 120 counties 20 have planning commissions but many are not active. 16 area development districts have no enforcement authority but have completed interim land use plans for entire State.	
Tennessee	Counties and municipalities have authority to plan and zone but not all do.	
Alabama	1969 Acts provide for creation of State Planning Division and 12 regional planning and development districts. There are no special zoning enabling laws.	1974 CZM Act was passed.

TABLE 5. INSTITUTIONAL AND LEGAL LAND USE CONSIDERATIONS IN THE EASTERN INTERIOR REGION (Coffin, 1974)

State	Land use		Power plant siting	Strip mining
	Current status	Legislative actions		
Illinois	No statewide land use policies or programs.	No land use policy foreseen soon.	Illinois Commerce Commission issues permits. No specific legislation.	Laws do not require return of land to original contour but do require extensive revegetation.
Indiana	No statewide land use policy.	1974 Federal land use bill was killed and this affected chances for state bill. Governor's Land Use Study Commission is not active.	The Environmental Management Board is conducting study to develop legislation.	Permit is not required if overburden is less than 19 ft thick. In 1972, State had largest number of regulatory employees per number of active mines. 1972 law requires annual permit; to get permit a fee of $15/acre, a performance bond, and a proposal for reclamation are required. Reclamation must be concurrent with mining and maximum slope angles during reclamation must be consistent with intended land use.
Kentucky	No statewide land use policy.	1974 bill created a land use planning council which will recommend legislation.	New law requires certification of environmental compatibility, which must be approved by Public Service Commission.	Spent more money in 1972 on regulating strip mining than any other state. Original contour must be restored and before permit is issued, applicant must have an erosion and silt control plan.

(continued)

TABLE 5. (continued)

State	Local land use controls	Coastal zone management
Illinois	Counties and municipalities have full planning and zoning authority. A measure that would have required localities to place greater emphasis on environmental zoning protection was killed. 13 area-wide planning agencies exist mainly in urban areas.	The state DOT regulations dredging. State is part of Federal CZM program.
Indiana	Localities and counties have been delegated full planning and zoning authority. Only 5 counties do not have planning organizations. 17 substate regional planning districts have been established.	Did not apply for CZM Federal money. Permits on a discretionary basis are granted for land fill.
Kentucky	Of 120 counties 70 have planning commissions but many are not active. 16 area development districts have no enforcement authority but have completed interim land use plans for entire State.	

TABLE 6. INSTITUTIONAL AND LEGAL LAND USE CONSIDERATIONS IN THE WESTERN INTERIOR REGION (Coffin, 1974)

State	Land use policy		Power plant siting
	Current status	Legislative actions	
Missouri	Under Government Reorganization Act the office of statewide planning has changed from providing advice and technical assistance to formulating and implementing policy and coordinating land use planning activities in the State.	Report is being prepared assessing impact of growth on critical and sensitive areas. Legislature killed a flood plain zoning bill. Environmental advisory group is examining extension of wetlands law.	Locally controlled with advice from State planning office.
Kansas	No statewide land use policy.	Legislative committees are studying the subject.	No special law.
Oklahoma	No statewide land use policy.	Technical Land Use Advisory Committee has been established to assist the state in preparing technically for federal legislation.	No special law.
Arkansas	No statewide land use policy.	Land use legislation or specific action may come in near future.	Certificate of environmental compatibility is required, based on public hearings. Public Service Commission makes decision on the following: 1) need for facility, 2) value to the public interest, 3) environmental impact, and 4) conformity to local, state and regional laws.

(continued)

TABLE 6. (continued)

State	Strip mining	Local land use controls	Coastal zone management
Missouri	Weak reclamation requirement and little actual reclamation. Cost of restoring land is prohibitive: $450-$500 per acre on land originally valued at $100-$200 per acre. Miners and farmers bear costs on a cost-sharing basis.	Only 22 of 144 counties have planning or zoning ordinances. Rural counties lack controls.	---
Kansas	5 year old law requires reclamation of mined areas. Lands strip mined more than 5 years ago have been taken off tax rolls.	Localities and counties have full zoning authority. There are 12 regional planning bodies with advisory powers.	---
Oklahoma	A mild strip mining law authorizes the operator to determine future land use for which the land will be reclaimed. The land must be revegetated unless it is to be covered with water or used for commercial sites.	Complicated and authority depends on site of community.	---
Arkansas	Act requires strip miners to establish escrow accounts for reclaiming stripped land.	Standard zoning enabling legislation but no counties are zoned.	---

TABLE 7. SUMMARY OF INVOLVEMENT OF STATE, REGIONAL, AND LOCAL GOVERNMENT AGENCIES IN SURFACE COAL MINING OPERATIONS

Agency	Functions
A. State agencies	
1. Mining and/or reclamation agencies	Issue mining permits after consultation with other state and Federal agencies involved. Conduct monitoring and enforcement of surface mining operations. Approve release of bond upon satisfactory completion of reclamation operations. In some states may issue a surface mine operator's license.
2. Water resources agency	The number of state agencies addressing water resources questions varies from state to state based on state governmental organization. Principal areas subjected to regulation include: 1. water utilization (withdrawals and consumption), 2. mine drainage, 3. flood plain obstructions, 4. water quality impacts, and 5. construction and operation of minor and major water impoundments. Mining operations that involve any of these areas will require at least approval and possibly a separate permit from these agencies.
3. Air quality and noise control agencies	Though they are not present in all states, where they do exist they generally must provide approval of the mine permit prior to issuance.
4. Transportation agencies	Review proposed coal haulage routes, regulate size and weight of coal haulage units, and issue highway occupancy permit.
B. Regional agencies	
1. River basin commissions	Set guidelines and priorities for water use and management within a river basin. Water allocation approval may be required.
2. ARC - Appalachian Regional Commission	Provides technical assistance through research and demonstration programs. Compiles demographic data within the Appalachian region useful for mine land planning.
3. TVA - Tennessee Valley Authority	Provides technical assistance and guidelines to operators within their jurisdiction primarily through research and demonstration programs.

(continued)

TABLE 7. (continued)

Agency	Functions
C. Local agencies	
1. Local planning (zoning) agency	Provides guidelines for postmining land uses primarily through its zoning power. May provide guidelines for various types of land use through its zoning ordinances, building and subdivision regulations, etc. Approval of mining plan--with particular emphasis on postmining uses--may be required.
2. SCS - Soil Conservation Service	Provides technical assistance locally to mine operators in areas of reclamation. May be required to review and approve erosion and sediment control plan for the operation.

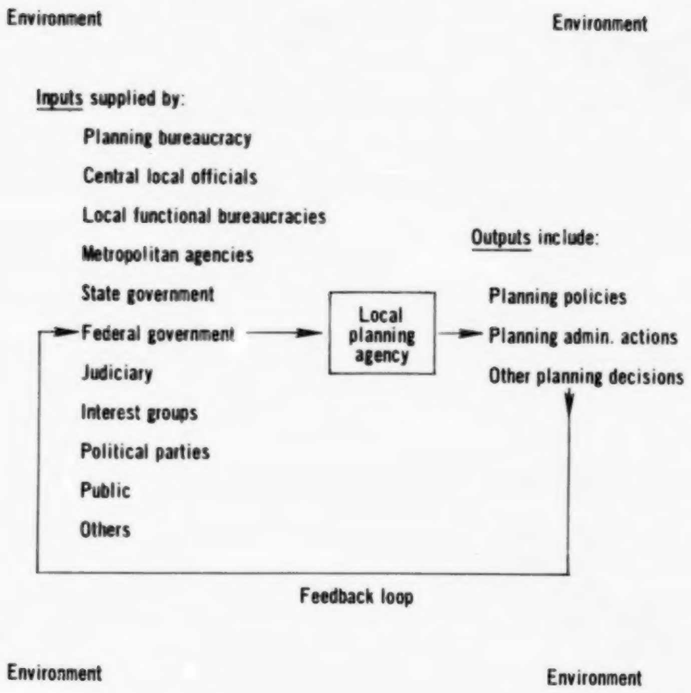
Environment
Environment
Inputs supplied by:
Planning bureaucracy
Central local officials
Local functional bureaucracies
Metropolitan agencies
State government
Federal government
Judiciary
Interest groups
Political parties
Public
Others
Local planning agency
Outputs include:
Planning policies
Planning admin. actions
Other planning decisions
Feedback loop
Environment
Environment

Figure 3. The political system of the local planning commission (Linowes and Allensworth, 1975).

groups of zoning regulations: building-size regulations, building-tract (area) regulations, density-of-population regulations, and use regulations.

Of the four main groups of regulations, the most important are use regulations. These regulations permit local governing bodies to divide a county into several kinds of zoning districts. Separate districts can be established for farming, homes, business, industry, forestry, recreation, flood control, conservation, etc. In the future, in each kind of district, only those proposed uses of land, buildings, and structures that are consistent with other uses need be allowed to become established; harmful uses can be excluded. Unwise mixtures of land uses can be avoided, and land uses that may conflict can be kept apart.

Zoning ordinances and related regulations are local laws passed by counties or other government units. Zoning-enabling statutes merely grant the power to counties or other governments or agencies; the ordinances zone the land. Zoning powers granted are usually permissive rather than mandatory. This means that a county, for example, may exercise all the powers granted, some of them, or none at all.

Zoning is carried out by dividing a community into several kinds of districts. Then, suitable kinds of zoning regulations can be applied in each type of district. These regulations will differ from district to district. For example, regulations applied in agricultural and forestry districts will be different from those applied in residential districts.

Building-tract regulations may be employed to set minimum restrictions on size of lots or tracts, setbacks, side and rear yards, and permissible lot coverage. Building-size regulations may be used to restrict the height and size of buildings and other structures as well as the number of stories permissible in them.

Building-tract and building-size regulations may be used to influence population densities and to assure adequate light and air around buildings. In areas with large lots and one-story houses, population densities are low; in areas with small lots and multistory houses, population densities are high.

The four main types of zoning regulations are very flexible. They can be used in a number of ways in towns, on the urban fringe, and in the open country areas--including forestry, recreation, and farm zoning districts--to attain community objectives. Zoning can be used to protect existing property values, to foster the development of new values, or to do both.

Zoning regulations are useful in areas on the urban fringe where land is used intensively for specific purposes, or in populous areas; only a few are useful in farm, ranch, or forestry districts.

Zoning Controls Related to Surface Mining Operations

A county or municipality can use the zoning power to control and regulate the occurrence, extent, and duration of surface mining operations to a considerable degree. The zoning controls that can be used to achieve this end are generally either purely locational controls or a combination of locational and performance controls. A thorough review of the use of these controls related to surface mining operations was prepared for Pennsylvania and is partially described below (Curry and Fox, 1978).

Locational Controls--

Locational controls can be achieved by one of two methods: (1) a total ban of surface mining, or (2) a restriction of surface mining to particular use districts.

Total ban of surface mining--Assuming that the municipality has, or is going to adopt, a general zoning ordinance, it may allocate a portion of its territory for strip mining activities and prohibit that activity in other portions. Except in rather limited circumstances, a zoning ordinance may not exclude strip mining altogether, either by express prohibition or silently by failure to provide for it. Normally, a zoning ordinance is entitled to a presumption of validity before the courts.

A municipality seeking to exclude all surface mining activities within its borders will have the burden of proving that the prohibition is necessary for the preservation of the public health, safety, welfare, or morals. To succeed in any effort to uphold a total prohibition, the municipality must demonstrate that certain conditions exist within its borders that make surface mining not simply undesirable but actually dangerous to the community. The municipality must point to specific harm that may result from the surface mining and must show that there are no alternate means by which the surface mining operations can be conducted to minimize or prevent that harm. It must show also that the specific harm is reasonably certain to occur if surface mining is permitted. Expert testimony and substantial factual evidence, both of the potential for harm and of the lack of alternative means to prevent that harm, will probably be required. Finally, the municipality must demonstrate that it was aware of the facts that give rise to these dangers before adoption of the prohibition and that the prohibition was adopted to prevent that harm.

With properly framed issues and the necessary factual basis, a total prohibition of surface mining can be sustained as a proper exercise of the zoning power in specific situations. For instance, if the municipality can show that, as a matter of fact, any surface mining within the municipality will result in irreparable injury to its public water supply or to the water supply used by other sources such as agriculture, or if surface mining would adversely affect fragile environmental areas, a total prohibition might be sustainable. If the only land suitable for surface mining (that is, the only land under which coal or other mineral resources capable of extraction by strip mining is located) is in public ownership and used for public purposes, a total prohibition could be sustained. In addition, other legitimate uses of the zoning power, such as the preservation of areas of historical importance, could justify a total prohibition in limited situations. In all of the cases of this kind, the facts demonstrating the adverse effect of the strip mining operation would have to have been developed before the adoption of the prohibition.

Restriction of surface mining to particular use districts--Even though most municipalities will not be able to sustain a total prohibition on strip mining, they need not permit it in all zoning districts. Of course, there must be coal or other minerals in those areas of the municipality where surface mining is permitted. However, if strip mining is permitted in some districts, it need not be permitted in all areas where these minerals exist. It can be excluded from use districts where strip mining is incompatible with other permitted uses. For example, an area presently developed or to be developed substantially for residential purposes could be regarded as an area incompatible with strip mining activity because of the dust, noise, traffic, and other effects assoicated with the mine operation. The same could be said of commercial and developed or developing industrial districts. Thus, municipalities can restrict strip mining to low intensity use districts, such as agricultural, open space, and so forth.

A word of caution is in order here. The zoning ordinance that permits surface mining in certain sections of the community will be entitled to the presumption of reasonableness and validity. However, a mine operator may still be able to show that the refusal to permit mining in an area not zoned for that activity is unreasonable because of the facts existing in that district. For example, if the area is zoned for residential uses but remains substantially undeveloped at the time an application for a mining operation is filed, a court may conclude that the denial of the permit is arbitrary and unreasonable under the then-existing state of facts. Communities that choose to regulate surface mining operations only by permitting them in certain use classification districts as outright permitted uses must be careful in selecting those districts.

It is possible to restrict surface mining operations to certain use districts, and to control their location further by reference to particular community facilities that the municipality desires to protect. For example, surface mining operations could be permitted in any agricultural district, provided that the actual removal of ground cover and minerals occurs no closer than 250 feet from the border of a stream. A similar provision also could be utilized to preserve public park land by restricting the surface mining operation to within a given distance of an existing park. The applicant for a permit would have to demonstrate that the proposed operation would meet this requirement and would be, as well, located in a use district where surface mining is permitted. In the event that subsequent operations under the permit are carried into the forbidden area, the use permit could be revoked for the entire operation and appropriate proceedings for enforcement of the ordinance would be brought by the municipality.

The municipality could create particular use classification districts, designated as mineral recovery districts, to permit surface mining and other compatible uses. These districts would be designed to assure availability of mineral resources for present and future extraction. By limiting the other types of uses that would be permitted in this district, many of the current problems facing mine operators and municipal officials could be alleviated. The model mineral reservation ordinance developed in Wisconsin represents such an effort (Friz, 1975; Preston et al., 1974).

Combined Locational and Performance Controls--

All of the preceding types of controls treat surface mining activities simply as permitted uses in particular zoning districts. These are usually the easiest and least expensive controls to administer. Other controls of a special permit nature involve a greater exercise of discretion on the part of the municipality. To withstand charges of arbitrary and capricious decision making, a greater amount of municipal expertise and information is necessary to support the exercise of this discretion. In return, the controls provide the municipality with flexibility and precision in selecting areas where surface mining can occur and in assuring that the mining operations are carried out in a way that is least harmful to the entire community.

The principal techniques for regulating land use by special permit are the conditional use and the special exception. The conditional use is granted by the governing body, and special exception is granted by the zoning hearing board. These terms may be somewhat misleading. There is nothing special about a special exception, nor is it truly an exception to the uses permitted under the zoning ordinance. Both the special exception and the conditional use are uses permitted in particular zoning districts by the express terms of the zoning ordinance. However, these uses are allowed only when the applicant for a permit can show that the use will meet certain additional locational and operational criteria set forth in the zoning ordinance. In effect, the zoning ordinance asserts that this particular type of use can locate in a given zoning district only under conditions designed to assure that it will not be detrimental to other uses in the same district or to the community at large.

The conditions imposed by the ordinance are designed to place upon the applicant the burden of proving that its use will be compatible with other activities in that district and will not be harmful to the public health, safety, or welfare. Once the applicant has demonstrated that the conditions imposed by the zoning ordinance will be satisfied by its proposal, it is entitled to the permit unless others can convince the granting agency by appropriate evidence that the proposed use in that location will be injurious to the public health, safety, and welfare or that the impact of the use on the public interest would be greater than normally expected from uses of that type.

It cannot be overemphasized that all special exceptions and conditional uses must be listed in the zoning ordinances as allowed uses in specified districts under conditions designed to assure their compatibility with other permitted uses in the same district. If the use proposed by an applicant for land in a particular district is not allowed by right (sometimes called a permitted use) or as a special exception or conditional use, the applicant cannot be granted a special use permit.

Special use permits in general--The special exception and conditional use provide the municipality with a range of options for controlling the location of strip mining operations. These controls can be imposed with greater precision than the locational controls discussed earlier because of the discretion allowed the local permit granting agency. The conditions under which special permits are to be granted and the standards by which the agency is to be guided when considering applications must be set forth in the zoning ordinance.

These zoning techniques enable the municipality to regulate both the location of surface mining operations and, to the extent that the zoning power has not been preempted by the state or Federal statutes, the offsite effects of those operations. Locational decisions can be controlled in two ways. First, surface mining may be allowed as a special use only in selected use classification districts. Second, among the conditions that can be imposed on the granting of the permit are varying setback or other requirements that depend upon the uses of adjoining lands. For example, a setback of 1,000 ft from adjoining residential or commercial uses of land might be required where large numbers of people are present. If the adjoining land is being used as private open space or for certain agricultural purposes, a setback of only 100 ft might be more reasonable. This degree of fine tuning would not be as easy to apply or administer under locational controls that treat surface mining simply as a permitted use. Furthermore, to assure that truck traffic from the operation does not travel on underdesigned or congested roads within the municipality or create a danger for residents by passing through residential or commercial areas unnecessarily, the special use permit could be conditioned upon the applicant's agreement to use only certain routes acceptable to the municipality. This requirement could be imposed instead of, or in addition to, any requirements established by a valid road ordinance.

For municipalities that wish to go further in assuring that any new surface mining operations will not adversely affect their citizens, the special use permit affords them that opportunity. The burden is upon the applicant to show that its proposed use will meet the standards set forth in the ordinance before a use or occupancy permit is issued. The applicant may be required to establish that the proposed mining operation will not have an adverse impact upon the community or upon stated community environmental values. The applicant could be required to establish, for example, that the proposed operation will not pollute or diminish public or private water supplies. Though the municipality may not be able to regulate the manner in which explosives will be used in the mining operation, it can require the applicant to establish, insofar as possible, in advance of the granting of the permit that its proposed use of explosives will not cause injury to structures on nearby lands or substantially diminish underground water sources.

Postmining usefulness of the land--Another feature of surface mining directly related to the protection of significant community values that can be achieved through the special use technique is control of the usefulness of the land once mining operations have been completed or have ceased for a given period of time. The municipality can attempt to prevent the mined-out land from becoming a burden to its taxpayers. Both the state and Federal statutes regulating surface mining require minimum physical reclamation of newly mined lands. These statutes do not preclude local land use requirements with respect to the usability of the land once mining operations have ceased. They require only that the reclaimed land present no actual or probable threat to the public health and safety and no danger of water pollution and diminution. They specifically permit reclamation consistent with local land use plans. Thus, the municipality can insist that the land remaining after mining be left in a condition that will enable it to be used for ecologically and economically productive purposes consistent with proposed long-range uses allowed in the zoning district where the mine was located.

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The applicant for a proposed surface mining operation may assert that mining is a necessary activity to prepare the land for some other permanent use. It may be necessary to remove voids, spoil piles, or other remnants of previous surface or deep mining activity to make the land area sufficiently stable to support residential, recreational, or industrial development. In this and other appropriate situations, the local permit granting agency may want to insist that the applicant demonstrate a commitment to the postmining utility for the land by requiring that a proposed or tentative subdivision and land development plan be included in the special permit application. Any order granting the use permit should be framed in such a way that it cannot be construed as preliminary subdivision approval of the plan. Otherwise, the municipality may be precluded from further review of the proposed permanent development once mining operations have been completed.

Rather than insist upon a detailed reclamation plan--e.g., installation of sewer and other underground utilities and roads sufficient to support a residential community that may never be built--the municipality may require the applicant to present a plan for reclamation that will result in land at least as productive as that area before mining. This approach can protect the tax base of the community and provide opportunities for future development of the area in accordance with community objectives. It is a fair request, as well as an appropriate one, since the extraction of the minerals has permanently deprived the community of valuable resources, as well as a part of its tax base.

Pace of mining operations--Special use permits may also be employed to control the pace of mining in the community. Often the sheer magnitude of mining in a municipality can result in problems that exceed the community's ability to respond effectively. Road deterioration from several widely separated operations may exceed the fiscal capacity of the community to make necessary repairs. The problems that result from numerous mining operations working simultaneously may simply overwhelm local officials, preventing them from addressing any single problem adequately.

Case law from elsewhere, and the language of Pennsylvania decisions, suggests that the special use permit may provide some degree of control over the pace of mining activity, provided that the conditions imposed for issuance of the permit can be shown to be reasonable. Regulations may be utilized to accomplish any one or more of the following objectives: (1) control of the amount of land under active surface mining at any particular time, (2) relating the amount of new land allowed under mining to the effectiveness of the reclamation of preceding operations, and (3) creation of incentives for the remining of inadequately reclaimed mining sites.

These controls operate on the assumption that the municipality is not employing them to prevent strip mining but to assure that when strip mining occurs, it will be under conditions within the municipality's ability to respond to the problems that it will present.

One method for controlling the pace of mining activity is to impose a maximum acreage limitation on the amount of surface land within the municipality that may be under active mining at any one time. Once permits have

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been issued for this maximum acreage, no further permits can be issued until one of the existing operations is completed. Unlike most zoning regulations, which can operate prospectively only, the municipality could impose this control immediately to include existing active surface mines in the calculation of the maximum acreage allotment.

Determining the maximum acreage limit for any municipality is one of the most difficult problems to resolve when imposing this control. The maximum must be reasonable in relation to the total amount of available mineral resources in the municipality. It should be related to the carrying capacity of existing and proposed roads, available potable public and private water supplies, and similar considerations of the public health, safety, and welfare. One way to fix the maximum is to refer to the existing acreage under active mining adding an amount of land determined by the average annual increment in acreage over the past 5 years.

Once the area under active mining approaches the limit set in the ordinance, additional areas can be permitted by special use only as existing lands are reclaimed in accordance with all applicable regulations. As each acre of land under active mining is certified by the appropriate municipal agency to be adequately reclaimed, an additional acre becomes available for new mining operations. Even when the acreage under active mining has approached the maximum, the municipality should continue to process applications for new mining permits. The permits could be issued subject to a certification of availability of sufficient acreage. This method will enable operators to know that use can be made of their mineral rights and should encourage continuous efforts by existing operators to reclaim land as the mining progresses. This is a requirement, in any event, under the Federal act. No additional burden is imposed upon the operator.

This approach offers several advantages to the municipality. It assures that the amount of mining conducted at any one time will not exceed the community's capacity to respond to the problems that the mining may create. It also provides a realistic incentive for mine operators to reclaim land as expeditiously as possible. By encouraging quick cover of slopes and cuts and by minimizing the time the subsoil is exposed, municipalities can be certain also that threats of water contamination, erosion, sedimentation, and flooding are kept to a minimum.

In addition, this technique may offer incentives to operators seeking to remine previously mined but unreclaimed or inadequately reclaimed land. The simplest incentive would be to permit remining without regard to the maximum established for new mining. Another would be to grant limited exemptions from the new mining maximum for operators willing to undertake reclamation of old sites. A relationship or ratio could be established between the amount of the exemption and the amount of land remined. For example, for each acre of old workings reclaimed, the operator might be allowed to mine two acres of new workings without regard to the maximum applicable to new mining in general.

No set ratio can be suggested for all municipalities. Each must develop a formula that will fit its particular needs. To arrive at a reasonable and defensible formula, the municipality should consider the amount of unreclaimed land it has, the likelihood that economically recoverable coal or other resources are present in the old sites, the size of the maximum limit on new operations to be adopted, the amount of coal or other resources that can be recovered through new mining, and other similar factors. Particular municipalities may wish also to adapt this approach to encourage remining and elimination of spoil piles and other waste disposal areas created by former mine operations.

Selection of appropriate special permit technique--However simple or sophisticated the special use procedure selected by the municipality, it will have to select granting of permits by the governing body--a conditional use--or by the zoning hearing board--a special exception. Conditional uses are often applied only to activities that may have community-wide impact and that require the exercise of a substantial amount of discretion. Special exceptions are commonly employed to control activities having a more localized impact and requiring less discretion on the part of the granting agency. Nevertheless, the two are more similar than different. Both provide a method for individual treatment of particular land uses within the general municipal zoning scheme. Both allow for a determination, in advance of any application for a use permit, that certain types of land uses will be acceptable in a particular zoning district only if the eventual applicant can prove that the use will be carried out in a manner that is not harmful to the community or to other uses permitted in the same district. In accomplishing this objective, the municipality may require the applicant to agree prior to issuance of the permit--to comply with certain conditions set forth in the ordinance. Failure of the permit holder to meet those conditions can result in revocation of the permit.

Under both procedures, the applicant can be required to demonstrate that the proposed method of operation will meet the requirements of the ordinance for a special use permit. Both procedures afford the permit granting agency some amount of discretion in passing upon particular applications. The particular use will be authorized as a conditional use or special exception in the zoning ordinance. That ordinance must contain standards and criteria to guide the agency in its consideration of applications for a special use permit. The agency may attach additional conditions to its grant of permit if authorized by the ordinance to do so and if the conditions imposed are reasonably designed to promote the expressed objectives of the zoning ordinance. It is important to remember, however, that the courts will scrutinize the conditions imposed to ensure that they are within the power of the granting agency and are not arbitrary or capricious.

In Pennsylvania, the differences between conditional uses and special exceptions are more procedural than substantive. A conditional use may be granted by the governing body only after review of the application by the municipal planning agency and recommendations from that agency to the governing body. An unsuccessful applicant can appeal a denial of a conditional use application directly to court. Any other person aggrieved by grant of the permit must appeal that action to the zoning hearing board and from there, if an adverse decision is reached by the board, to court.

A special exception can be granted only by the zoning hearing board. The board's decision may be appealed to court by either the disappointed applicant or by any person aggrieved by that decision.

Before a decision on either a conditional use or special exception application can be made, the granting agency must hold a public hearing on the application after giving proper notice. At that hearing, interested parties must be afforded an opportunity to present evidence in support of or in opposition to the application and to cross-examine witnesses presented by other parties. A record of the hearing must be maintained in the event of an appeal.

A legislative body is not particularly suited to conduct the type of hearings that may be required for some of the controls suggested in this report. Because of the technical nature of the controls and of the information that may be necessary for their proper application, the hearings may require several days or evenings to complete. Nor should the fact be overlooked that the political nature of strip mining controls may pose difficult situations for members of the governing body. Because the essential requirements for the exercise of discretion under either the conditional use or special exception are so similar, the choice between the two is also a political one that must be resolved by each municipality.

Where all other considerations are equal, however, the special exception seems better than the conditional use. Technical controls that require analysis of technical data usually can be administered more efficiently and more consistently by those persons most familiar with the day-to-day operation of the zoning ordinance. The members of the governing body may better spend their time considering matters of legislative importance for the overall operation of the municipality than administering the zoning ordinance. In arriving at this conclusion, no attempt is made to bypass the governing body. The zoning hearing board is responsible to it and derives its power to act on special exceptions from the governing body. It must act in accordance with the criteria and standards set forth by that body. The major advantage in delegating the application review function to the board is an increase in the efficiency of the municipal government.

From the point of view of rational land use controls, a particular advantage of the conditional use procedure is the requirement of application review by the planning agency. The local permit granting agency is provided then, with a source of expertise that may be necessary to review technical information required by the application, to determine if those requirements have been met, and to evaluate the impact of the proposed use on the municipality.

SECTION 4

GEOGRAPHIC FACTORS

OVERVIEW

Geographic factors that embody a combination of spatial, economic, and market considerations include: location, accessibility, size and shape of the site, and the status of surrounding lands, particularly with respect to ownership and intensity of use. Together these factors will, to a large extent, determine the demand and thus the value of the site for various land use types.

LOCATION

Unlike many of the other uses of the land surface, there is only a limited choice in the location of mining operations. It depends, of course, on the natural location of the mineral deposits. The location of these deposits is generally well known at the macro level (Figure 4). This general location fixes many of the economic factors that affect land use. Superimposing Figure 4 on Figure 5, for example, will indicate the relationship between coal regions and major economic regions of the United States. Similarly, relationships between coal regions and related elements--such as climate, principal types of farming and crops, principal forest types, population, transportation, and many other elements--can be developed.

Geographic location establishes the proximity to a city and its developed facilities, such as transportation systems, power supply, labor pool, manufacturing and supply services, and specialty repair shops; all of these, if available, enhance the attractiveness of the site. The proximity to cities also increases the potential of the site for intensive postmining use.

If the mine site is near the periphery of urban growth, excellent potential will exist to develop the mined areas for an intensive urban use (Figure 6). Usually, however, the mine will be located outside the bounds of urban or suburban influence, and postmining land use will be dictated by the existing land use.

A study conducted by the U.S. Department of Agriculture on the status of surface mine lands revealed the following information related to the distance of surface mined lands from population centers (USDA, 1973):

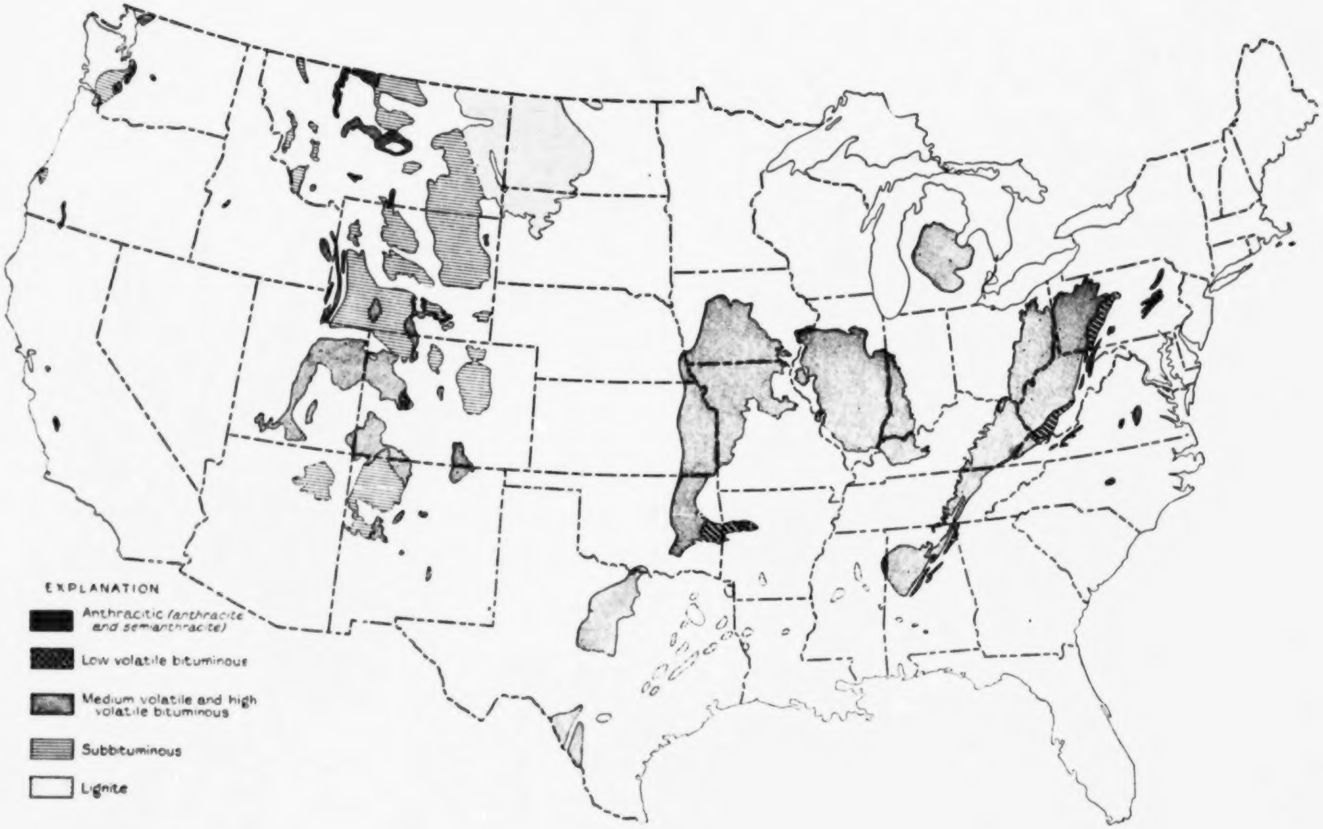
EXPLANATION
Anthracitic (anthracite and semianthracite)
Low volatile bituminous
Medium volatile and high volatile bituminous
Subbituminous
Lignite

Figure 4. Coalfields of the United States (USGS, 1970).

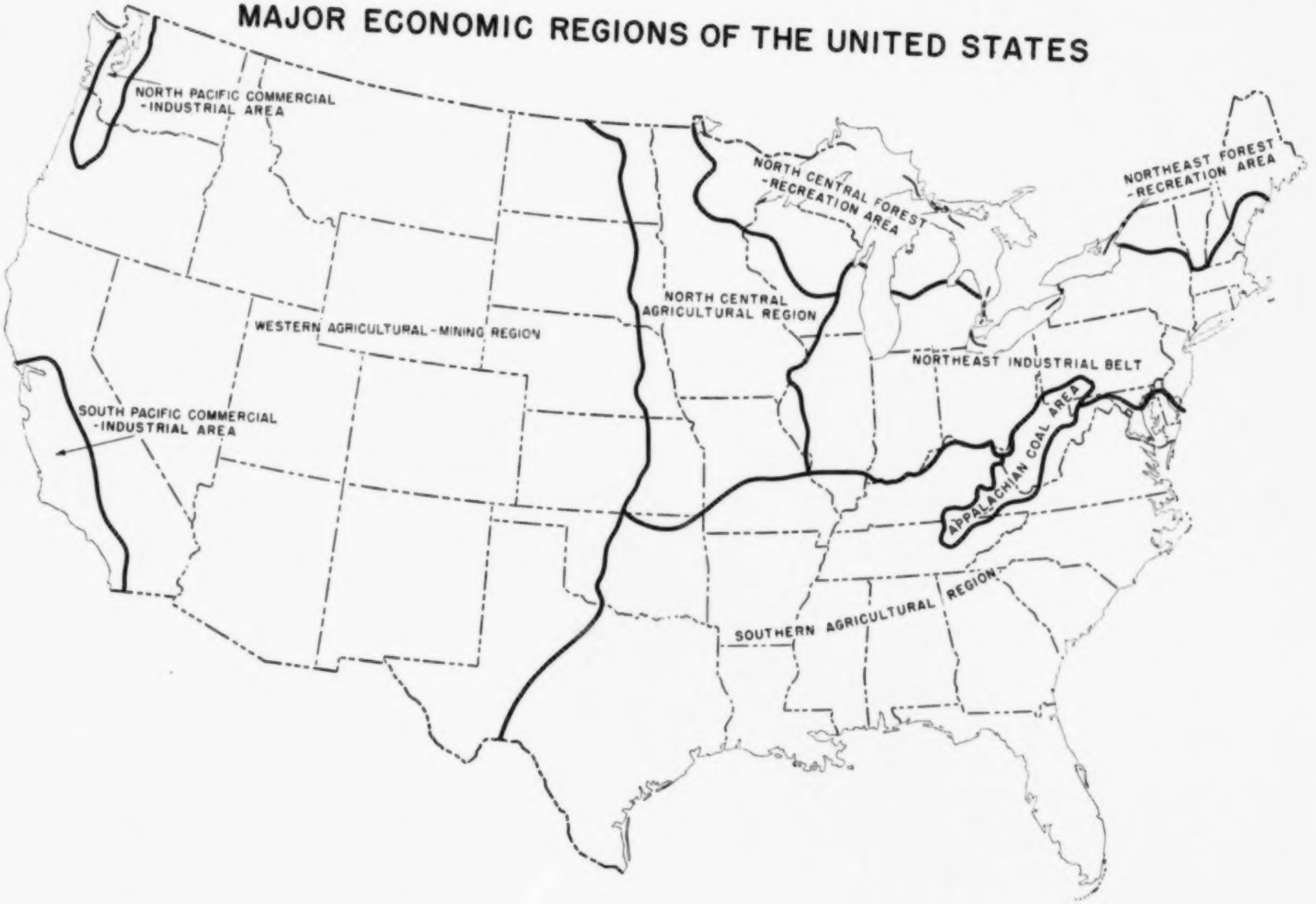
MAJOR ECONOMIC REGIONS OF THE UNITED STATES
NORTH PACIFIC COMMERCIAL -INDUSTRIAL AREA
SOUTH PACIFIC COMMERCIAL -INDUSTRIAL AREA
WESTERN AGRICULTURAL-MINING REGION
NORTH CENTRAL AGRICULTURAL REGION
NORTH CENTRAL FOREST -RECREATION AREA
NORTHEAST FOREST -RECREATION AREA
NORTHEAST INDUSTRIAL BELT
APPALACHIAN COAL AREA
SOUTHERN AGRICULTURAL REGION

Figure 5. Major economic regions of the United States (NRPB, 1943).

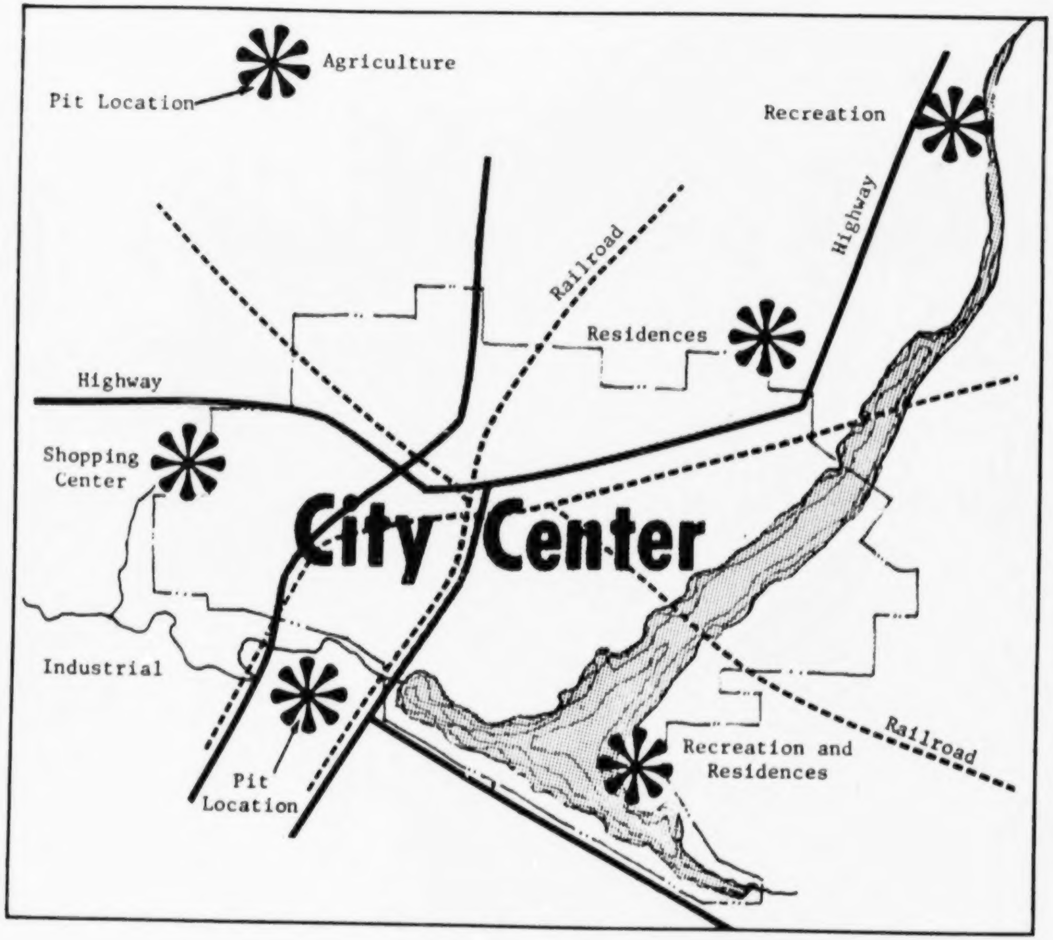
Agriculture
Pit Location
Recreation
Highway
Railroad
Residences
Highway
Shopping Center
City Center
Industrial
Pit Location
Recreation and Residences
Railroad

Figure 6. Location as a land use determinant (theoretical) (Jensen, 1967).

1. More than four-fifths of the mine lands surveyed were at least one mile from communities with a population of more than 200.
2. More than half of the mine lands surveyed were over four miles distant from the nearest town.
3. Forty percent of the mined land could not be seen from any U.S. highway or passenger railroad.
4. Most mined areas were close enough to communities for a family to reach it for an afternoon recreation outing.
5. No urban growth was evident around two-thirds of the mine lands, suggesting that the majority of these areas continue to remain in rural land use types such as forestry, agriculture, or recreational.

Figure 7 provides a summary of the proximity of surface mined-areas to population centers.

ACCESSIBILITY

The value of a parcel of land is directly related to the ease or difficulty of access to roads and streets and the availability of transportation facilities as well as other utilities, including water and gas mains, sewers, and electrical and telephone lines. In addition, other services such as mail delivery, police and fire protection, and garbage, trash, and snow removal are significant (Weimer and Hoyt, 1966).

A farm that is split in two by an express highway to which it has no access may be diminished in value. Land situated near express highway intersections is highly valued for commercial and industrial uses.

The accessibility of a site is often measured by two parameters--travel distance and travel time. Distances and corresponding travel times to schools, shopping centers, places of employment, churches, community centers, parks, and playgrounds are of special importance in considering the value characteristics of land used for residential purposes. In the case of business sites, the proximity and access to main arteries of pedestrian traffic and to parking areas is one of major importance. Likewise, nearness to transportation lines or terminals is of importance to industrial sites. Table 8 presents a summary of some time-distance standards that have been developed for selected uses in urban areas.

Surface mining operations generally increase the accessibility of a given site. This increase is due to the addition of haul roads necessary for hauling the coal to the preparation plant. Sometimes rail lines are provided that may be restricted to onsite operations or that may provide a spur to a trunk line. It is also not uncommon to provide electric and telephone lines to the site. All of these positive aspects of the mining operations should be recognized.

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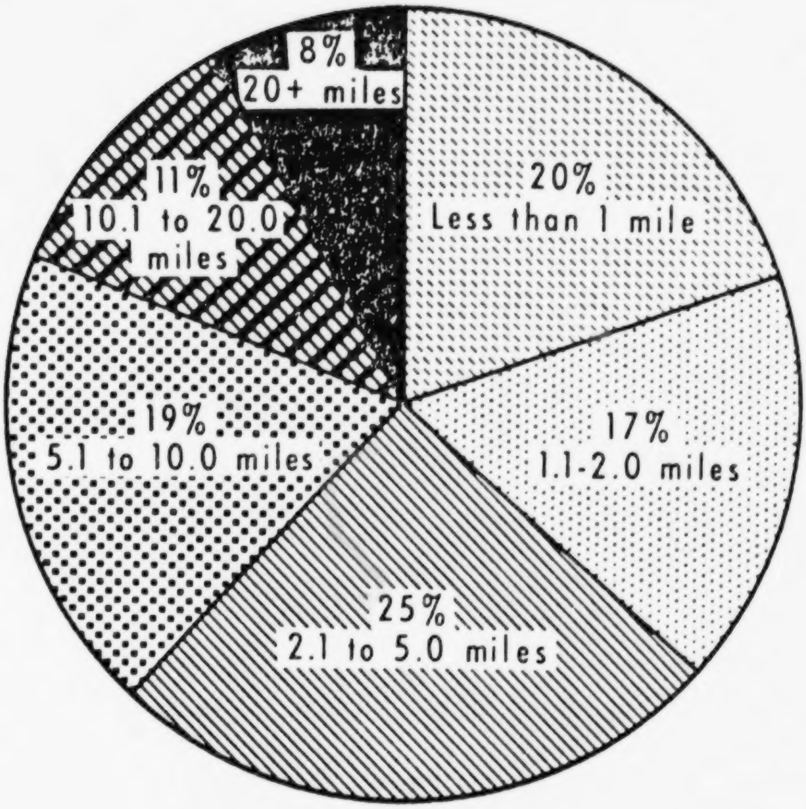

Figure 7. Proximity of surface-mined areas to population centers (USDA, 1973).

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TABLE 8. ILLUSTRATIVE TIME-DISTANCE STANDARDS FOR SELECTED USES IN URBAN AREA OF 100,000 POPULATION (Chapin, 1965)

Use of facility	Controlling standards
Employment	20 to 30 min.
Central business district	30 to 45 min.
Local shopping center	1/2 mile or 10 min.
Elementary school	1/2 mile
Junior high school	1 mile or 20 min.
Senior high school	20 to 30 min.
Playgrounds and local parks	1/2 mile
Playfields and recreation centers	1 mile or 20 min.
Public park or reservation	30 to 60 min.

SIZE AND SHAPE OF THE SITE

Urban lot sizes are usually measured in m^2 (ft^2) or the number of meters of frontage on the street and depth in meters. Farms and other rural real estate are measured in terms of hectares (acres) or sections (square mile--640 acres). Obviously, a lot with only 9 m (30 ft) of frontage cannot be used as the site for a tall office building or a large department store. Size is an important factor in determining use, and use in turn has a very direct bearing on income-producing ability. Size also determines effectiveness of use; a case in point is the trend toward larger farms as agriculture becomes more highly mechanized. Value, of course, is not directly proportional to size. Up to a point, additions to the size of a parcel of land tend to increase its income-producing ability and hence its value; thereafter, such additions tend to be of diminishing importance.

The relationship between frontage and depth is important for many types of urban real estate. In the case of residential land, for example, there has been an increasing demand for lots with wider frontage and with somewhat shallower depth. Few lots of less than 15 to 18 m (50 to 60 ft) in width are considered adequate for residential development, and those of wider frontage, around 30 m (100 ft), tend to be more salable. Lots used for business and industrial purposes vary greatly in width and depth, depending on the specific uses to which they are put.

The new town concept, in which a golf course, private parks, sites for industries, schools, churches, and shopping centers are provided, gives added plottage value to a 16- or 20-hectare (40- or 50-acre) tract when it is part of or adjacent to another tract of 200 to 300 hectares (500-700 acres).

The shape of the land parcel may determine the possible uses to which it may be put and hence affect its income-producing ability. While lots of irregular shape often may be used to advantage for residual purposes, regularity is usually desirable for business, industrial, or agricultural uses. Many developers of new residential areas now plan lots of irregular shape, adapting

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them to curvilinear streets, cul-de-sacs, and park areas. This practice contrasts sharply with the gridiron pattern formerly followed almost exclusively in subdivision planning. The gridiron pattern often resulted in lots of odd shape, however, when diagonal streets were involved.

Surface coal mine sites exhibit a great deal of variation in size and shape. These sites can vary in size from 4 to 6 hectares (10 to 15 acres) of annual disturbance for small independent operation to sites ranging from 120 to 200 hectares (300 to 500 acres) for the giants of the industry.

The shape of the site is closely related to the type of mining systems used. Contour mining operations result in long, narrow strips of reclaimed land that are best suited for reforestation. Variations of contour mining, including mountaintop removal and valley fill operations, can result in substantial amounts of level land suitable for many uses. Modified area and area mining methods restore the land to its approximate original contour.

SURROUNDING LAND USES

The status of the neighboring lands, particularly with respect to ownership, type and intensity of use, and future trends has a strong influence on the suitability of the mine land to support various activities. In general, the use adopted at any specific site should be compatible with surrounding uses in terms of the following elements:

1. Views,
2. Prevailing winds,
3. Protective belts of planting,
4. Open space,
5. Noise, and
6. Access routes.

A land use map of the mine site and surrounding areas, such as that illustrated in Figure 8, provides the basis for this analysis (Jensen, 1967).

Ownership

Most surface mine lands are privately owned. Ownership of these lands can be shown simply, as follows (USDA, 1973):

Type of ownership:	%
Public ownership:	
Federal	5
State/local	4
Subtotal	9
Private ownership:	
Mining industry	52
Farm	23
Other	16
Subtotal	91
Total	100

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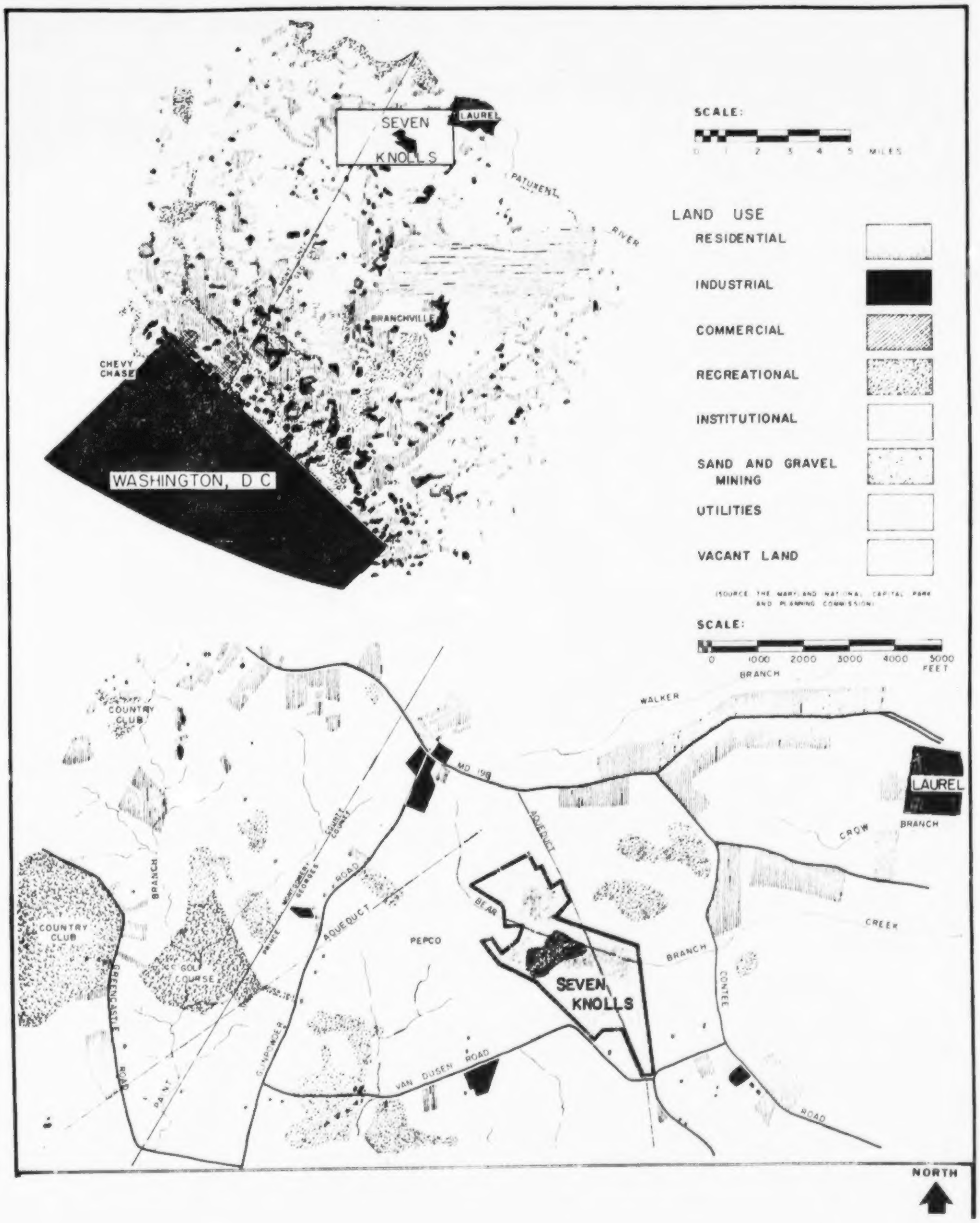
SEVEN KNOLLS
LAUREL
SCALE:
0 1 2 3 4 5 MILES
PATUXENT RIVER
BRANCHVILLE
CHEVY CHASE
WASHINGTON, D.C.
LAND USE
RESIDENTIAL
INDUSTRIAL
COMMERCIAL
RECREATIONAL
INSTITUTIONAL
SAND AND GRAVEL MINING
UTILITIES
VACANT LAND
(SOURCE: THE MARYLAND NATIONAL CAPITAL PARK AND PLANNING COMMISSION)
SCALE:
0 1000 2000 3000 4000 5000 FEET
WALKER BRANCH
COUNTRY CLUB
MD 198
AQUEDUCT
CROW BRANCH
LAUREL
COUNTRY CLUB
GOLF COURSE
BRANCH
PRINCE GEORGES COUNTY
ROAD
AQUEDUCT
PEPCO
BEAR BRANCH
SEVEN KNOLLS
CREEK
CONTEE
ROAD
GREENCASTLE ROAD
PAINT
GUNPOWDER
VAN DUSEN ROAD
NORTH

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Figure 8. Land use map showing mining site and vicinity (Jensen, 1967).

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Ownership of the land and of mineral resources can often provide a source of significant conflict. In many instances, the surface and mineral ownerships have been separated. Often the right to extract the mineral resources is contingent upon providing a postmining land use plan that is acceptable to the owner of the surface rights.

One of the first tasks of the mining venture should be the preparation of a map that properly identifies the status of both the land and coal ownership. Figure 9 illustrates such a map.

Type and Intensity of Use

A USDA survey of mine lands showed that many were scattered small acreages best treated as part of the total conservation management of the farm and other areas with which they are intermingled (USDA, 1973). Nearly 80 percent of the sites were in forest, farm, or grassland or were reverting to forest at the time of the survey. These same uses were being made of land adjacent to 86 percent of the sites. Less than 2 percent of the acreage had been set aside solely as outdoor recreation or wildlife areas; usually these are compatible with other uses of the land.

Surface coal mining operations are seldom permitted adjacent to highly urbanized areas. Typically the surrounding land will be undeveloped or at best used for agriculture, silviculture, and related activities. It must be kept in mind, however, that the land use selected may in turn restrict the development potential of adjoining property. Communities within the coal regions should carefully study and map their patterns of growth and expansion and seek to apply zoning control mechanisms such as those discussed in Section 3 to minimize the loss of valuable coal resources to urban expansion. When adequately planned and properly integrated into comprehensive planning efforts, surface coal mining operations can provide an excellent sequential use of the land.

Zoning, extensive ruggedness, or some feature of the site such as a lake may limit the land available for actual development. Housing units allowed by zoning may also limit the degree of development or the use intensity of the site. Similarly, the size of industrial buildings may be limited by steep slopes or yield of crops restricted by poor quality soils.

In some instances disposition of the site can be insured by providing buildable land either through partial mining of the site or creation of sanitary wasteland fills when economically feasible to assure sufficient land for use. Figure 10, an example developed for a sand and gravel operation, shows that a site that is mined except for the minimum setback area may well leave the periphery lacking sufficient land for a proposed use. On the other hand, varying the setback width and creating peninsulas of waste sand material will not only provide adequate land but can increase the amount of land directly accessible to the lake (Jensen, 1967).

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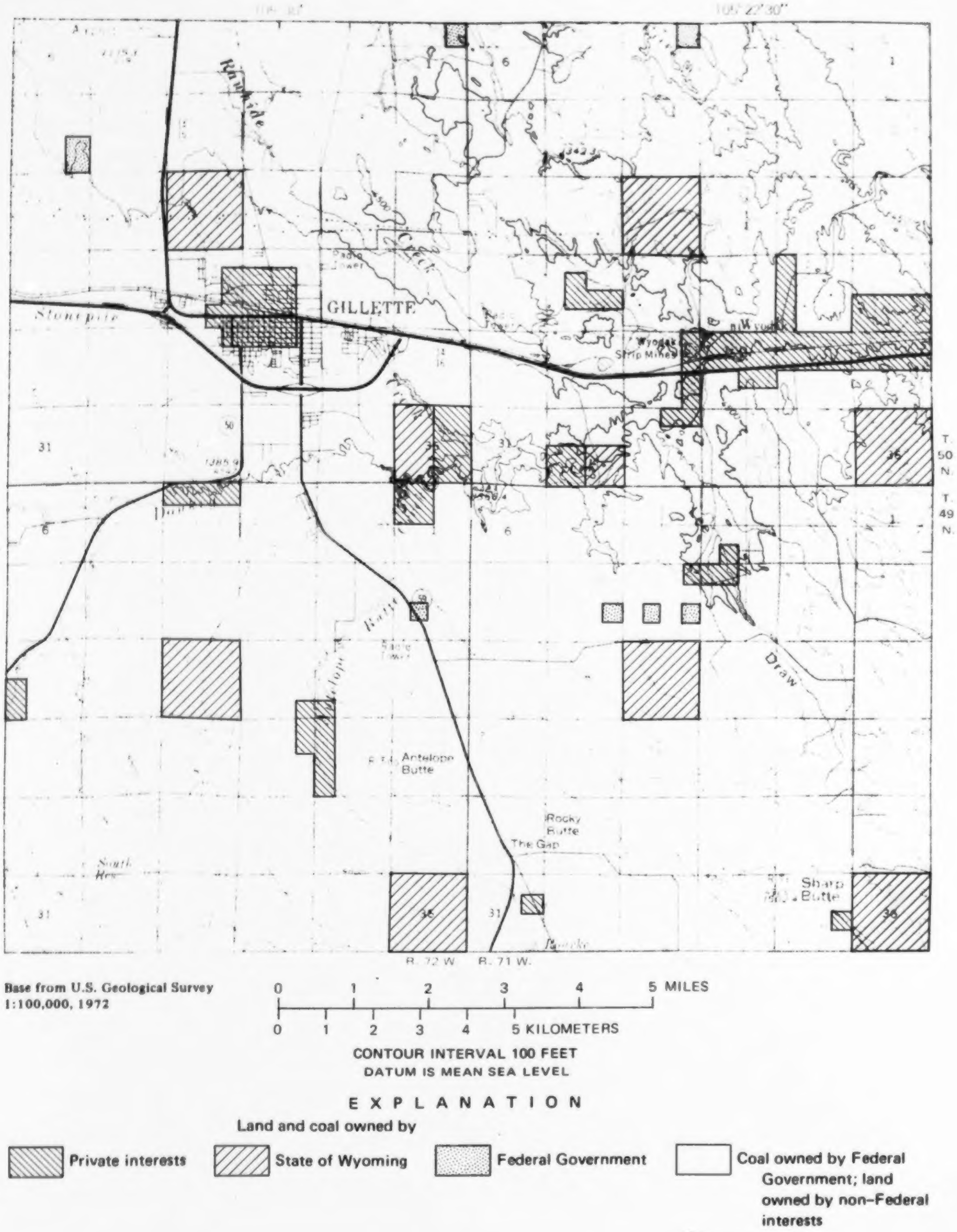
105°30'
105°22'30"
GILLETTE
Wyodak Strip Mine
The Gap
Rocky Butte
Antelope Butte
Sharp Butte
Draw
T. 50 N.
T. 49 N.
R. 72 W.
R. 71 W.
Base from U.S. Geological Survey 1:100,000, 1972
0 1 2 3 4 5 MILES
0 1 2 3 4 5 KILOMETERS
CONTOUR INTERVAL 100 FEET
DATUM IS MEAN SEA LEVEL
EXPLANATION
Land and coal owned by
Private interests
State of Wyoming
Federal Government
Coal owned by Federal Government; land owned by non-Federal interests

Figure 9. Land and coal ownership map of the Wyodak-Anderson coal deposit in the vicinity of Gillette, Wyoming (Keefer and Hadley, 1976).

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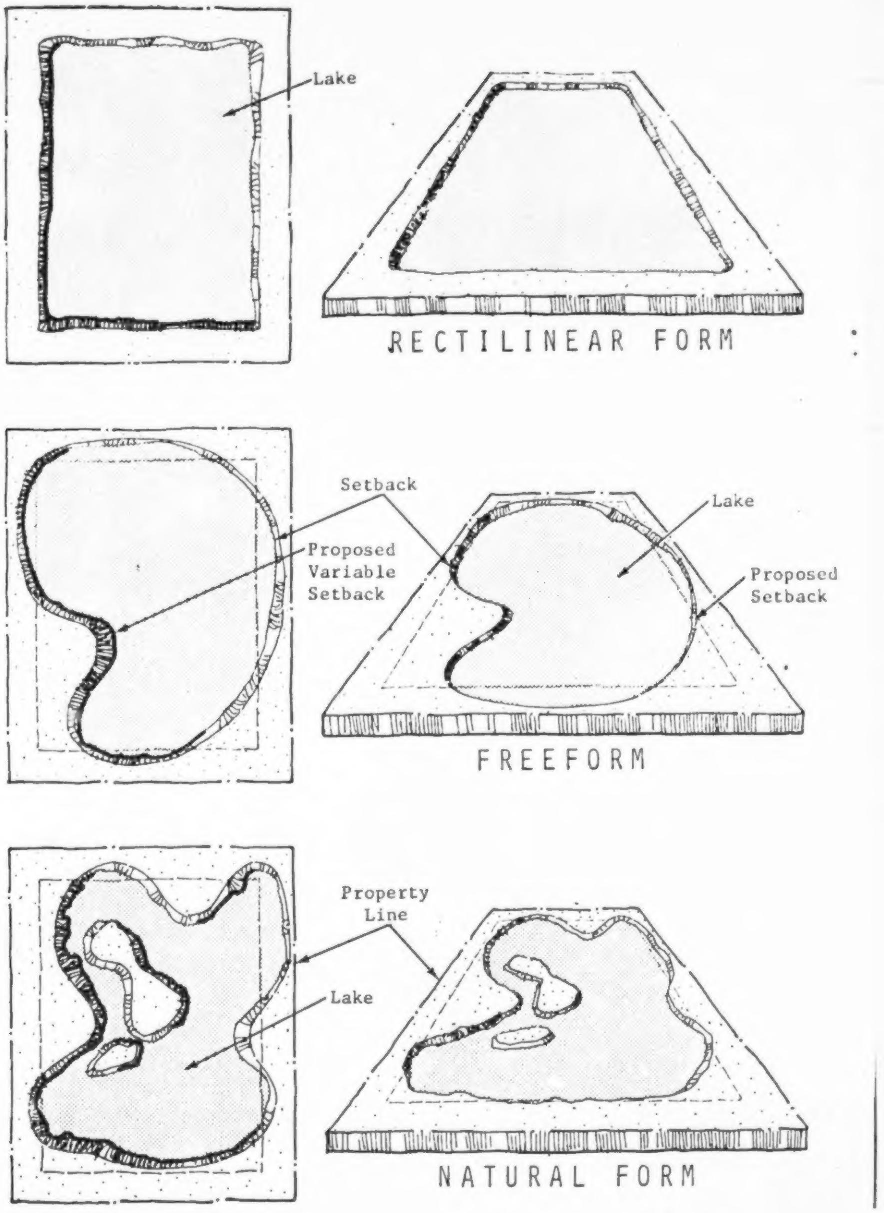
Lake
RECTILINEAR FORM
Setback
Lake
Proposed
Variable
Setback
Proposed
Setback
FREEFORM
Property
Line
Lake
NATURAL FORM

Figure 10. Lake-form potentials with constant property and lake size (Jensen, 1967).

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EFFECTS OF MINING OPERATIONS ON GEOGRAPHIC FACTORS

Surface coal mining operations have their greatest impact on the accessibility and the status of adjacent land uses. The construction of haul and access roads to the mine site can have both positive and negative impacts on the community. On the positive side, the construction of these roads can be integrated into overall community development plans and serve to upgrade the transportation network within the community. These roads together with the other utilities often necessary for a mine operation--including electric and telephone lines, the development of water supply sources, and the development of surface facilities, such as repair shops and housing--have the potential to serve as a basis for development of that area to support a wide variety of uses once the mining is completed. On the negative side, where the coal haul routes are tied into existing road and highway systems and, in particular, where the truck traffic is directed through existing communities, the impacts can range from being a general nuisance to endangering the safety of motorists and pedestrians and often can result in deterioration of the existing road system.

Viewed from a broader perspective, a large-scale increase in coal production within a large community or region can trigger a number of interrelated socioeconomic factors that can greatly alter the status of that region. Figure 11 traces both the positive and negative impacts of this scenario (Hittman, 1976). These additional demands placed upon the community as byproducts of increased coal production must be recognized by the local and or state planning agencies and factored into the comprehensive community planning process. This publication does not directly address itself to methods and approaches available for an orderly integration of mining operations into the community development process with the exception of the zoning controls previously presented in Section 3. However, the potential that exists to integrate mineral extraction operations and, in particular, surface coal mining operations into an orderly and sequential community development process is not only recognized but is emphasized as an important priority for planning authorities at the local and state level.

SUMMARY

A brief review of the major geographic factors and their influence on the suitability for various land use types has been presented. Table 9 provides a summary of the relative importance of the five factors discussed in determining the suitability of a parcel of land for supporting various land use types. Promoting residential, commercial, or industrial development in mined land is greatly affected by the geographical location, accessibility, and existing land uses and intensity of these uses. Geographical factors influence only to a very limited extent the development of mined land for forestry and wildlife or for agricultural purposes. Additional discussion of the relationship among geographic factors and the various land use types is provided later in this report under the discussion of site considerations for the various land use types.

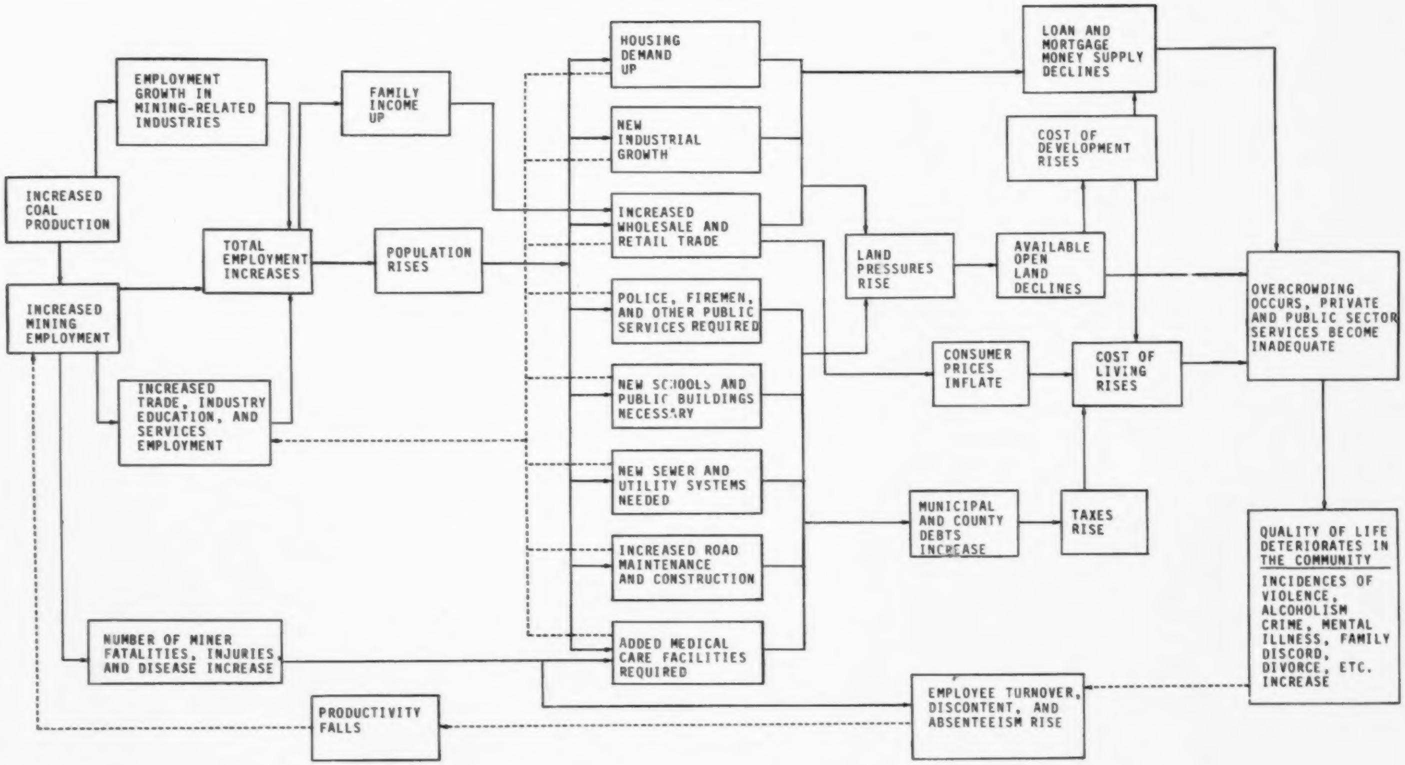
INCREASED COAL PRODUCTION
EMPLOYMENT GROWTH IN MINING-RELATED INDUSTRIES
INCREASED MINING EMPLOYMENT
TOTAL EMPLOYMENT INCREASES
INCREASED TRADE, INDUSTRY EDUCATION, AND SERVICES EMPLOYMENT
FAMILY INCOME UP
POPULATION RISES
NUMBER OF MINER FATALITIES, INJURIES, AND DISEASE INCREASE
PRODUCTIVITY FALLS
HOUSING DEMAND UP
NEW INDUSTRIAL GROWTH
INCREASED WHOLESALE AND RETAIL TRADE
POLICE, FIREMEN, AND OTHER PUBLIC SERVICES REQUIRED
NEW SCHOOLS AND PUBLIC BUILDINGS NECESSARY
NEW SEWER AND UTILITY SYSTEMS NEEDED
INCREASED ROAD MAINTENANCE AND CONSTRUCTION
ADDED MEDICAL CARE FACILITIES REQUIRED
LAND PRESSURES RISE
CONSUMER PRICES INFLATE
MUNICIPAL AND COUNTY DEBTS INCREASE
EMPLOYEE TURNOVER, DISCONTENT, AND ABSENTEEISM RISE
LOAN AND MORTGAGE MONEY SUPPLY DECLINES
COST OF DEVELOPMENT RISES
AVAILABLE OPEN LAND DECLINES
COST OF LIVING RISES
TAXES RISE
OVERCROWDING OCCURS, PRIVATE AND PUBLIC SECTOR SERVICES BECOME INADEQUATE
QUALITY OF LIFE DETERIORATES IN THE COMMUNITY
INCIDENCES OF VIOLENCE, ALCOHOLISM CRIME, MENTAL ILLNESS, FAMILY DISCORD, DIVORCE, ETC. INCREASE

Figure 11. Social and community impacts of rapid mining expansion (Hittman, 1976).

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TABLE 9. RELATIVE IMPORTANCE OF GEOGRAPHIC FACTORS AS DETERMINANTS OF LAND USE SUITABILITY

Land use types	Geographic factors				
	Location	Accessibility	Size & shape	Surrounding land uses	Intensity of use
Forestry and wildlife	3*	3	3	3	3
Recreational	1	2	3	2	3
Agricultural	2	3	1	3	3
Residential	1	1	2	1	1
Institutional	1	1	2	1	2
Commercial	1	1	1	1	1
Industrial	1	1	1	3	2

* 1 = Factor has high degree of influence on suitability of site for that particular land use.
2 = Factor has moderate degree of influence.
3 = Factor has low degree of influence.

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SECTION 5

CLIMATIC FACTORS

OVERVIEW

Climatology is an important consideration when determining the suitability of mined lands for various land use types. The factors that are influenced by and/or influence climate are so numerous and complex that it is beyond the scope of this publication to provide a complete description. The discussion that follows addresses only the following major climatic considerations:

1. Temperature,
2. Humidity,
3. Precipitation,
4. Solar radiation, and
5. Wind.

The climatic factors can be considered fixed for any given site. It is generally beyond the capabilities of man to modify these climatic conditions (though some cloudseeding operations, which are highly controversial, are practiced) and therefore it is very important to obtain an accurate description of the site climatology and to incorporate these factors into the planning and design of the mine site as much as possible.

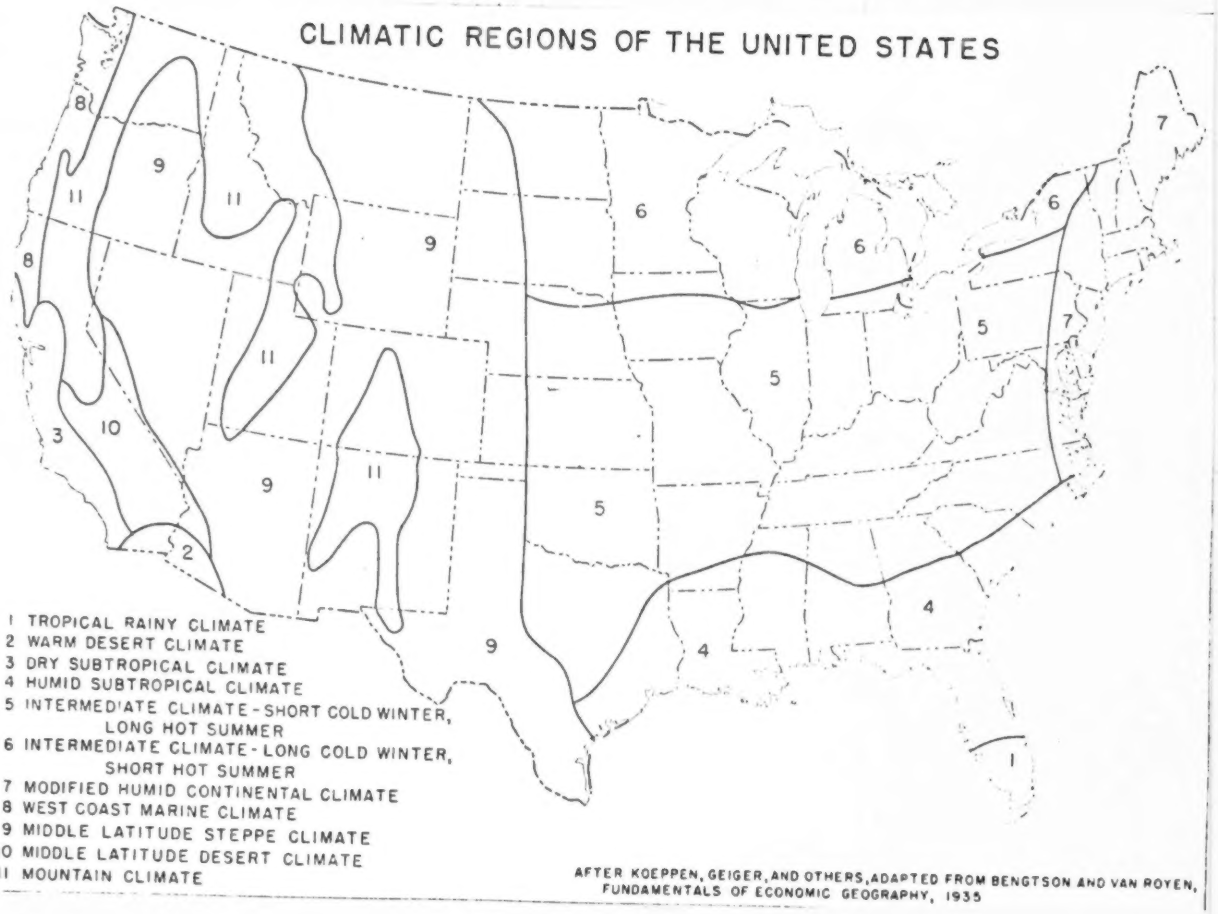
CLIMATIC REGIONS

The continental United States is divided into eleven different climatic zones (Figure 12). The eastern and interior coal regions fall principally into one major climatic zone, Zone 5, characterized by an intermediate climate with short cold winters and long hot summers. Also included, but to a much lesser extent, are Zones 4, 6, and 7 with the following characteristics:

Zone 4 - humid subtropical climate,
Zone 6 - intermediate climate--long cold winter, short hot summer, and
Zone 7 - modified humid continental climate.

TEMPERATURE

Temperature is an important climatic factor that often acts as a constraint, particularly to agricultural and silvicultural land uses. Cyclic


CLIMATIC REGIONS OF THE UNITED STATES
1 TROPICAL RAINY CLIMATE
2 WARM DESERT CLIMATE
3 DRY SUBTROPICAL CLIMATE
4 HUMID SUBTROPICAL CLIMATE
5 INTERMEDIATE CLIMATE - SHORT COLD WINTER, LONG HOT SUMMER
6 INTERMEDIATE CLIMATE - LONG COLD WINTER, SHORT HOT SUMMER
7 MODIFIED HUMID CONTINENTAL CLIMATE
8 WEST COAST MARINE CLIMATE
9 MIDDLE LATITUDE STEPPE CLIMATE
10 MIDDLE LATITUDE DESERT CLIMATE
11 MOUNTAIN CLIMATE
1
2
3
4
5
6
7
8
9
10
11

AFTER KOEPPEN, GEIGER, AND OTHERS, ADAPTED FROM BENGTSON AND VAN ROYEN, FUNDAMENTALS OF ECONOMIC GEOGRAPHY, 1935

Figure 12. Climatic regions of the United States (NRPB, 1943).

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and seasonal changes in temperature determine the length of the growing season, which is of prime concern for agricultural purposes--specifically plant growth.

The length of growing season is a major design factor in scheduling reclamation operations. It has a direct impact on both regrading activities and establishment of a permanent vegetative cover.

It is difficult and sometimes impossible to perform regrading operations in cold weather. Frozen ground or excessive snowfall can both shut down these operations. In addition, grading operations in early spring are strongly discouraged because of the high potential for slope failures and erosion losses. Temperature considerations should play a strong role in scheduling both the mining and reclamation operations.

Temperature Data (USDA, 1941)

A large number of data are usually required to properly identify the basic climatic characteristics of a locality. The most significant data for the purpose include:

1. Average daily temperature,
2. Average daily range and average daily variability,
3. Average monthly temperature,
4. Average monthly range and absolute monthly extremes,
5. Seasonal temperature, especially the average for the summer (June through August) and for the winter (December through February),
6. Average annual temperature and average annual range, and
7. Frequency of occurrence and duration of certain significant temperatures.

The mean daily temperature is the basic climatic unit. The mean monthly temperature is the average of the daily values for the month and, in practice, the average annual temperature is the mean of the 12 monthly mean values. Monthly minimum and maximum temperature ranges for states within the study region are provided in Volume 3 of the series, Geology of Eastern Coal Fields.

The true average daily temperature corresponds closely to the average of 24 hourly observations, but as several other combinations of hourly values give averages that differ little from the true daily average, some of these are generally used to reduce computational work. The formula

$$\frac{(\text{maximum} + \text{minimum})}{2}$$

is an easy application that is very satisfactory when dependable maximum and minimum thermometers are used and properly exposed, as at official weather bureau stations. The mean of the daily extremes is, as a rule, slightly too high, but it usually does not vary more than half a degree from the true daily average. This is the combination employed by the weather bureau to obtain the average daily temperature.

The meteorological seasons differ somewhat from the astronomical seasons because the temperature lags considerably behind the apparent alternating annual north and south march of the sun. For example, in northern latitudes, the sun's altitude is lowest about December 22, nearly a month before the average coldest weather of winter, which occurs about the middle of January. The year is divided into four seasons of three months each, and the coldest consecutive three months are, on an average, December, January, and February. This period, therefore, makes up the meteorological winter. March, April, and May form the meterological spring; June, July, and August constitute summer; and September, October, and November make up fall. Seasonal averages are averages for the three months of the meteorological season.

The average winter and average summer temperatures are especially important because in the northern portions of the United States and at higher altitudes in the west the three summer months coincide more or less with the growing season for potatoes and corn, while the winter temperature shows many interesting correlations with the northern limit of winter wheat and several tree fruits. Just as the mean daily temperature is approximately the average of the maximum and minimum, so the annual mean is represented very closely by the average of the extreme months, January and July. The difference between this and the mean for the 12 separate monthly means in most sections of the country is only a fraction of a degree. A number of these data, including length of growing season and temperature extremes, have been compiled for the study regions and are included in Volume 3 of the series.

Temperature and Planting Dates (USDA, 1941)

Though the time of lowest or highest temperature for individual years may vary considerably from year to year, the normals, or long-time averages, show a uniform march from the low of winter, about January 15, to the high of summer, about July 15, and then a recession back to the winter low. The spring rise in the annual temperature march has some interesting relations to agricultural operations. For example, the usual date of the beginning of spring wheat seeding is the time when the normal daily temperature rises to 37°F in the locality where seeding is to be done; for spring oats it is 43°F; for early potatoes it is 45°F; for corn it is 55°F; and for cotton it is 62°F. Incidentally, 55°F, the corn-planting temperature, comes at the time of the average date of the last killing frost in spring, and 62°F, the cotton-planting temperature, comes after the last killing frost.

Killing Frost and Length of Growing Season (USDA, 1941)

The growing season of crops susceptible to frost damage--the warm-weather crops--is restricted by the number of days between the last killing frost in the spring and the first in the fall. Maps and tabular data show for the country as a whole, and for individual states, the average dates of the last killing frost in the spring and the first in the fall, together with the average length of the period between these dates, usually referred to as the growing season. These data are included in Volume 3.

On some of the Florida keys freezing temperatures have never occurred, and consequently the frostless season covers the whole year. However, these are the only localities in the United States completely frost-free. Throughout most of Florida, along the coast of the Gulf of Mexico, and in favored localities in Arizona and California, the average growing season, however, is more than 260 days. Along the northern margin of the cotton belt it is about 200 days, and in the northern part of the corn belt it is from 140 to 150 days. In northern Maine and northern Minnesota, where hay, potatoes, oats, and barley are the principal crops, it is about 100 days, and in the higher altitudes in the West less than 90 days.

There is very little agriculture, except wild hay production and grazing, when the average season between spring and fall killing frosts is less than 90 days. In such regions frosts are likely to occur in any of the summer months. The length of the season without killing frost varies year by year, as indicated by records for selected stations for the several states.

HUMIDITY

The amount of moisture in the air is strongly interrelated with the hydrologic regime of the mine site and therefore is a factor of major importance. Atmospheric humidity yields clouds, rain, and snow and affects the rate of evaporation and the passage of heat--and thus nocturnal cooling and daytime warming. Humidity includes consideration of numerous parameters such as relative humidity, dew point, evaporation, and precipitable water.

Relative humidity (f) is a term that is expressed as the ratio of the actual to the saturation vapor pressure and is therefore a ratio of the amount of moisture in a given space to the amount the space could contain if saturated (Linsley et al., 1958). Therefore:

$$f = 100\ e/e_s$$

where, e = actual vapor pressure
e_s = saturated vapor pressure

A representation of average relative humidity in the continental United States during the months of January and July is provided in Volume 3. The relative humidity for the study regions can be seen to vary from a low of 45 percent in the western interior coal province to a high of 60 percent in the southern end of the eastern coal province.

Whenever the air is saturated with water vapor, a temperature fall initiates condensation. The temperature at which condensation commences is called the dew point (T_d). This temperature is characterized by having a

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saturation vapor pressure e_s equal to the existing vapor pressure e. Rapid and large-scale condensation results in foggy conditions that are undesirable for many human activities, particularly travel.

The rate of evaporation or vaporization depends upon the relative humidity of the air in contact with the moist surface and thus data on the amount of evaporation gives additional information about humidity. In addition, the rate of evaporation is influenced by solar radiation, air temperature, vapor pressure, and wind. Annual values of evaporation for the continental United States are provided in Volume 3 of this series. As indicated on the map, evaporation rates range from approximately 178 cm (70 in.) in the western interior coal province to 102 cm (40 in.) in the eastern coal province.

PRECIPITATION

Atmospheric moisture is the immediate source of supply for precipitation that may occur in the form of rain, snow, sleet, hail, or dew. The volume of precipitation interacts with several other factors--including atmospheric pressure, temperature, solar radiation, wind, humidity, evaporation, and the geology and geomorphology of an area--to determine its potential for water resource availability. The availability of water resources is a major factor in determining the potential of an area for resource development.

A water supply deficiency, such as encountered in the arid regions, not only makes reclamation of mined lands difficult but essentially precludes any type of postmining development. In the humid regions, which include all of the study area, the situation is reversed. Excessive rainfall can represent a major design problem for various reasons, including:

1. High water tables and the need to dewater the mine,
2. Surface erosion potential,
3. Acid mine drainage problems, and
4. Flooding hazards at the mine.

On the other hand, however, the availability of larger water supplies provide excellent potential for any type of land use development ranging from recreational through industrial uses.

Precipitation Data

Several types of precipitation data are usually required to properly identify the precipitation characteristics of an area. These data include:

1. Annual average,
2. Seasonal averages,
3. Monthly normals,
4. Daily averages and frequency of various common amounts of rain,
5. Hourly distribution, and
6. Local contrasts in precipitation.

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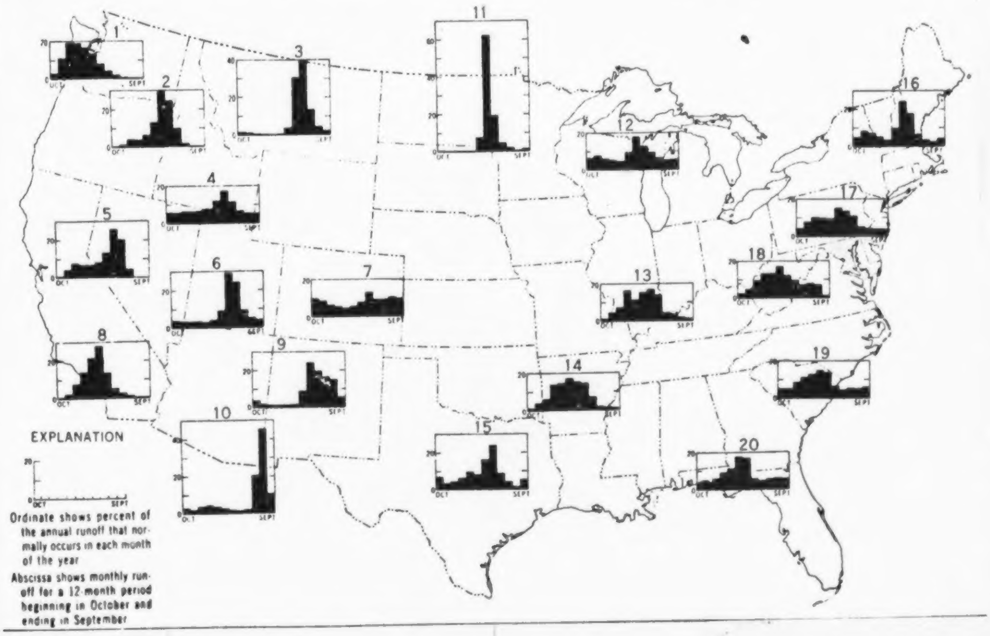
The basic precipitation data are the average annual amounts. These are provided in Volume 3. However, the annual values are insufficient for an adequate appraisal of moisture conditions, especially as they affect crops, produce floods, etc. The seasonal distribution--that is, whether or not the rain falls at a time of year when it will be most beneficial to growing crops--as well as the intensity of the rainfall--that determines whether or not the amounts falling are absorbed largely by the soil or mainly lost into streams and rivers, possibly producing floods--the frequency of droughts, and many other aspects of precipitation that cannot be determined from the annual, or even monthly, totals are all important factors. Figure 13 provides a graphic illustration of the seasonal fluctuation of normal monthly runoff distribution for selected regions of the United States. In recent years the importance of microclimatic observations has become more and more apparent. The more detailed records are most valuable in studying the geographic variations and differences in intensity of rainfall from place to place for contiguous localities.

The main source of precipitation and other climatic data is the National Climatic Center of the Environmental Data and Information Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce. The National Climatic Center publishes hourly, daily, monthly, seasonal, and annual precipitation data for a nationwide network of weather stations. The



Ordinate shows percent of the annual runoff that normally occurs in each month of the year

Abscissa shows monthly runoff for a 12-month period beginning in October and ending in September

Figure 13. Normal monthly distribution of runoff on 20 representative streams, 1931-1960 (Bryson and Hare, 1974).

Climatic Summary for the United States summarizes monthly and annual data from beginning of record to 1950.

SOLAR RADIATION

This factor is particularly important with respect to land uses for agriculture and forestry. The chief source of energy for green plants and all life depending upon them is solar radiation. It is absorbed by plants directly as heat and is also transferred by them into potential chemical energy. Since green plants are dependent upon light for the synthesis of their food supply, light has long been recognized as one of the major factors influencing growth, development, and reproduction of vegetation.

WIND

Though wind is not considered generally to have a direct or strong influence on land use suitability, it is a factor that should be recognized for design purposes. Wind action can result in significant soil losses in large flat areas such as those generally encountered in the midwestern states. Wind breaks can be effectively used to control a wind problem.

Areas that are subject to strong gusting winds can represent a stability hazard for the very large pieces of excavating equipment currently being used on some operations.

The major impact of wind, however, is on vegetation, particularly forest vegetation. Wind indirectly affects vegetative growth through its influence on humidity of the air in immediate contact with the vegetation, upon soil moisture and evaporation, and upon transpiration (Toumey and Korstian, 1947). It also affects pollination and seed distribution. Wind plays a large role in the distribution of atmospheric precipitation and in this way indirectly affects vegetation.

EFFECT OF MINING OPERATIONS ON CLIMATIC FACTORS

The climatic factors are generally fixed for a given location in response to large-scale continental systems. Consequently mining operations have very little influence on these factors, particularly at the macroscale level. To date, however, very little research and inquiry in this area has been conducted.

Mining operations can have some impact on microscale climatic factors, such as near-surface temperature and humidity and soil temperature and moisture. However, the majority of these impacts should be of a short-term nature and should return to normal once the site has been properly revegetated.

An area of significant impact is the relationship that exists between precipitation and runoff. Though no changes have been reported as yet in the volume and distribution of precipitation, significant changes in the volume and distribution of runoff have been reported. Runoff is dependent on, among other factors, the type and extent of vegetal cover, the degree and length of slope and infiltration, and the permeability of the soils and subsoils--all factors that can be greatly modified by the surface mining operations. Consequently, the relationships that exist among these variables should be carefully determined before mining so that adequate control and restructuring of these elements can be achieved during the reclamation process.

SUMMARY

A brief summary of the major climatic factors and their influence on the suitability for various land use types has been presented. Table 10 provides a summary of the relative importance of the five factors discussed in determining the suitability of a parcel of land for supporting various land use types. The most important aspect of the climatological factors with respect to the capability of mined lands to support various land use types is the determination of the ease with which revegetation can be established and sustained. Particularly significant are the temporal fluctuations in temperature and precipitation (i.e., daily, monthly, seasonal, and annual) and length of the growing season. Agricultural and forestry development plans, therefore, are greatly influenced by the climatological factors--favorable climatological factors are, in fact, essential for success. On the other hand, favorable climatic conditions, though desirable, are not essential in developments for residential, commercial, or industrial uses.

Additional discussion of the relationship among climatic factors and the various land use types is provided later in this report under the discussion of site considerations for the various land use types.

TABLE 10. RELATIVE IMPORTANCE OF CLIMATIC FACTORS AS DETERMINANTS OF LAND USE SUITABILITY

Land use types	Climatic factors				
	Temperature	Humidity	Precipitation	Solar radiation	Wind
Forestry and wildlife	1*	1	1	1	1
Recreational	2	2	2	2	2
Agricultural	1	1	1	1	1
Residential	3	3	3	3	3
Institutional	3	3	3	3	3
Commercial	3	3	3	3	3
Industrial	3	3	3	3	3

* 1 = Factor has high degree of influence on suitability of site for that particular land use.
2 = Factor has moderate degree of influence.
3 = Factor has low degree of influence.

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SECTION 6

GEOMORPHIC FACTORS

OVERVIEW

Geomorphology* has been defined as the science of landforms (Thornbury, 1969). This branch of geology includes factors considered by many to be the most important influences in determining the suitability of a site for various land uses. These factors include topography, altitude and relief, slope, exposure, and drainage.

The material presented in this section is intended primarily to identify these geomorphic factors and to review the natural limitations that these factors can impose on the suitability of a mine site to support various land use types. At the same time, it must be remembered that these factors have a strong influence on the mining operations themselves. Topography and slope in particular are closely related to the type of mining machinery that can be used and the selection of an appropriate extraction technique.

The discussion in this section is directed principally to microscale or site specific considerations. However, a brief summary of the major physiographic provinces within the three coal regions covered by this report is presented in Volume 3 to provide the reader with a macroscale overview of the existing geomorphic features.

TOPOGRAPHY

Topography consists of a three dimensional mapping of the land and its physical characteristics. Topographic maps are a detailed record of a land area, giving geographic positions and elevations for both natural and man-made features. They show the shape of the land--the mountains, valleys, and plains --by brown contour lines (lines of equal elevation above sea level). In steep mountainous areas contours are closely spaced; in flatter areas, they are far apart. The elevation of any point on the map can be estimated by referring to the elevations of the contour lines above and below it. This type of accurate representation is a primary requisite for the study, planning, and development of resources and a vital tool for engineering purposes.

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* Although the term geomorphology is preferred by geologists and engineers, other disciplines, notably geography, use the term physiography. These terms are synonymous in this report.

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Influence of Topography on Other Natural Factors

Topography and its relationships to climate, soils, hydrology, and plants is of concern to mine planners. The configuration or topographic relief of the land surface, the direction in trends of mountain chains, and the proximity to large water bodies must be considered together since these factors largely determine the direction of prevailing winds, humidity of the atmosphere, and amount of precipitation (Toumey and Korstian, 1947).

Though rainfall tends to be heavier on the windward side of a ridge than on the leeward side, windborne snow is likely to be carried over the crest and deposited on the leeward side. This can result in varying plant associations from one side of the ridge to the other. In addition, differences in rock formations--such as the difference in inclination of the strata--influence the soil water supply and the location of springs, two factors that also influence the type of vegetation to be found.

Because of the constant natural erosion process, areas below and adjacent to slopes usually have more fertile soil than neighboring slopes. Thus the soil of valleys and coves is deeper, richer, and more productive than the soil on the ridges and on the shoulders of hills. However, vegetation in the valleys and coves is more exposed to danger from frost, because cold air drainage causes the formation of frost pockets.

General topographic relief and the status of topographic mapping for the coal provinces covered in this study are discussed in Volume 3 of this series.

Use of Topographic Maps (USGS, 1976)

Industries and planning agencies use standard accuracy topographic maps of the U.S. Geological Survey as bases for more specialized maps. Scale and detail can be adjusted to suit individual needs. Specialized data can be superimposed directly on the topographic base map. Some of the special adaptations of topographic maps include:

Aeronautical charts
Census maps
County planning maps
Drainage basin maps
Flood zoning maps
Geologic maps
Industrial zoning maps
Land ownership maps
Land use and crop maps
National park maps
Physiographic maps
Population maps
Road maps
Shaded relief maps
Soil maps
Weather maps

Source of Topographic Maps

The U.S. Geological Survey is the basic source of topographic maps. Indexes showing published maps for each state are available free on request from the Branch of Distribution, U.S. Geologic Survey, 1200 South Eads Street, Arlington, Virginia, 22202 and also from Box 25286, Federal Center, Denver,

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Colorado, 80225. These indexes list special maps, addresses of local map reference libraries, local map dealers, and Federal map distribution centers.

Maps are available in varying scales, suited for varying uses. Large-scale maps, such as 1:24,000, are especially useful for highly developed areas or rural areas when detailed information is needed for engineering planning or similar purposes. Intermediate-scale maps, ranging from 1:50,000 to 1:100,000, cover larger areas and are especially suited for land management and planning. Small-scale maps--1:250,000, 1:500,000, and 1:1,000,000--cover very large areas on a single sheet and are useful for comprehensive views of extensive projects or for regional planning.

ALTITUDE AND RELIEF

The elements of altitude and relief are closely related to topographic considerations. Altitude, which is synonymous with elevation, refers to the height (in feet) above sea level. Specific elevations are shown on topographic maps in various ways and are usually located at centers of towns, on hilltops, and at bottom of depressions.

Relief is the difference in elevation between high and low points. The local relief of an area, or a mine site, may be easily determined by calculating the difference between the highest and lowest elevations on the site.

Altitude has a pronounced effect on climate. The atmosphere is less dense at higher altitudes and consequently is incapable of absorbing and retaining as much heat as is retained at lower altitudes. In a given latitude, a fall of 1°F in temperature results from a rise of 300 ft in altitude. This decrease in temperature accounts largely for the greater amount of precipitation on the windward side of mountains, ridges, or hills. The lowering of temperature, however, is greatly modified by the configuration of the land and by air currents. Valleys, coves, and ravines may be more exposed to danger from frost than the adjacent slopes several hundred feet higher in elevation (Toumey and Korstian, 1947). These various considerations are specially important in the selection of suitable vegetative species for stabilization or cultivation. Figure 14 is a map that provides approximate general altitudes in the United States.

SLOPE

Slope or gradient is the angle formed by the surface of the soil with the horizon; it indicates the relation of the surface of the site to the horizon. An important effect is the control that it exerts on runoff and drainage and, through these, upon water content of the soil. Another important effect is the control that it exerts through insulation on the temperature and moisture of the surface soil. Slope modifies the intensity of insulation by shifting the angle of incidence of the sun's rays. It also has some influence upon light, wind, and indirectly the distribution of snow.

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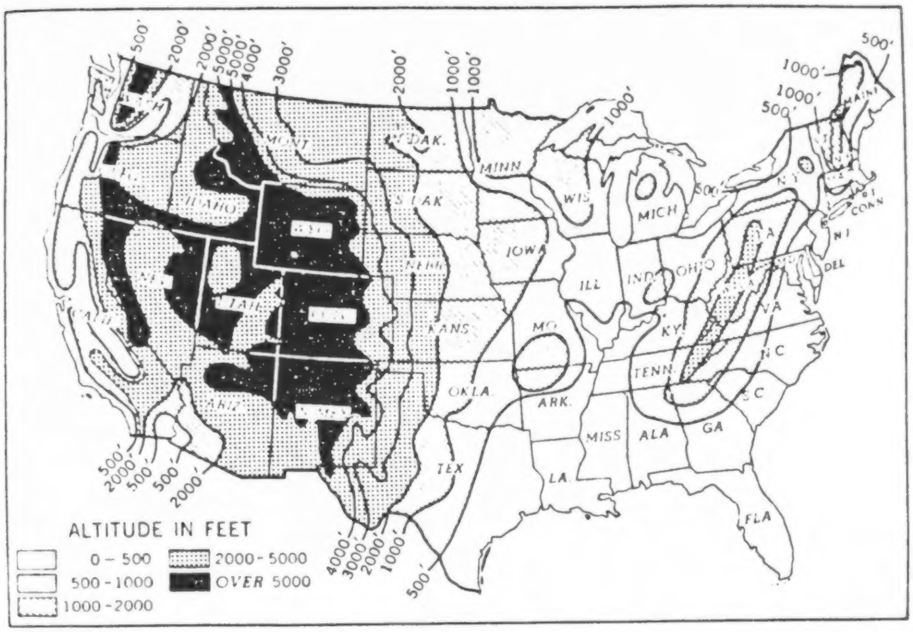
ALTITUDE IN FEET
0 - 500
500 - 1000
1000 - 2000
2000 - 5000
OVER 5000
500'
1000'
2000'
3000'
4000'
5000'
MONT
N DAK.
S DAK
MINN
WIS
MICH
IOWA
NEBR
KANS
OKLA
TEX
MO
ILL
IND
OHIO
KY
TENN
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FLA
N C
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CONN
N Y
MAINE
IDAHO
UTAH
ARIZ
CALIF
NEV

Figure 14. Approximate general altitudes of the United States (Martin et al., 1976).

The depth of soil and water content vary almost directly with the gradient when other conditions are similar (Toumey and Korstian, 1947).

It has been observed that the degree of slope is the most important limiting factor in cultivation. Likewise the degree of slope will limit the density of development that can occur. Residential, commercial, institutional, and industrial activities generally have similar slope requirements, ranging from 1 to 15 percent slope (the highest slope best suited for small buildings). Figure 15 provides a relative ordering of land use referenced to slope.

Slope Classification

The method most commonly used for the evaluation of the topographic characteristics of an area is known as slope analysis and consists of mapping of slopes grouped according to a slope classification. In order to produce a map of slopes, it is necessary to group the slopes of the area into some logical classification. Group limits may be set according to (1) arbitrary uniform intervals of gradient (for example, 0 to 5 percent, 5 to 10 percent, 10 to 15 percent, etc.), (2) the appropriateness of these limits to the gradients of the land under consideration (for example, 0 to 3 percent, 3 to 7 percent, 7 to 15 percent, etc.), (3) some characteristic of the ultimate purpose for which the map is being prepared (for example, 0 to 30 percent and 30+ percent for determining areas which may be traversed by a vehicle of certain performance characteristics), or (4) a combination of the above.

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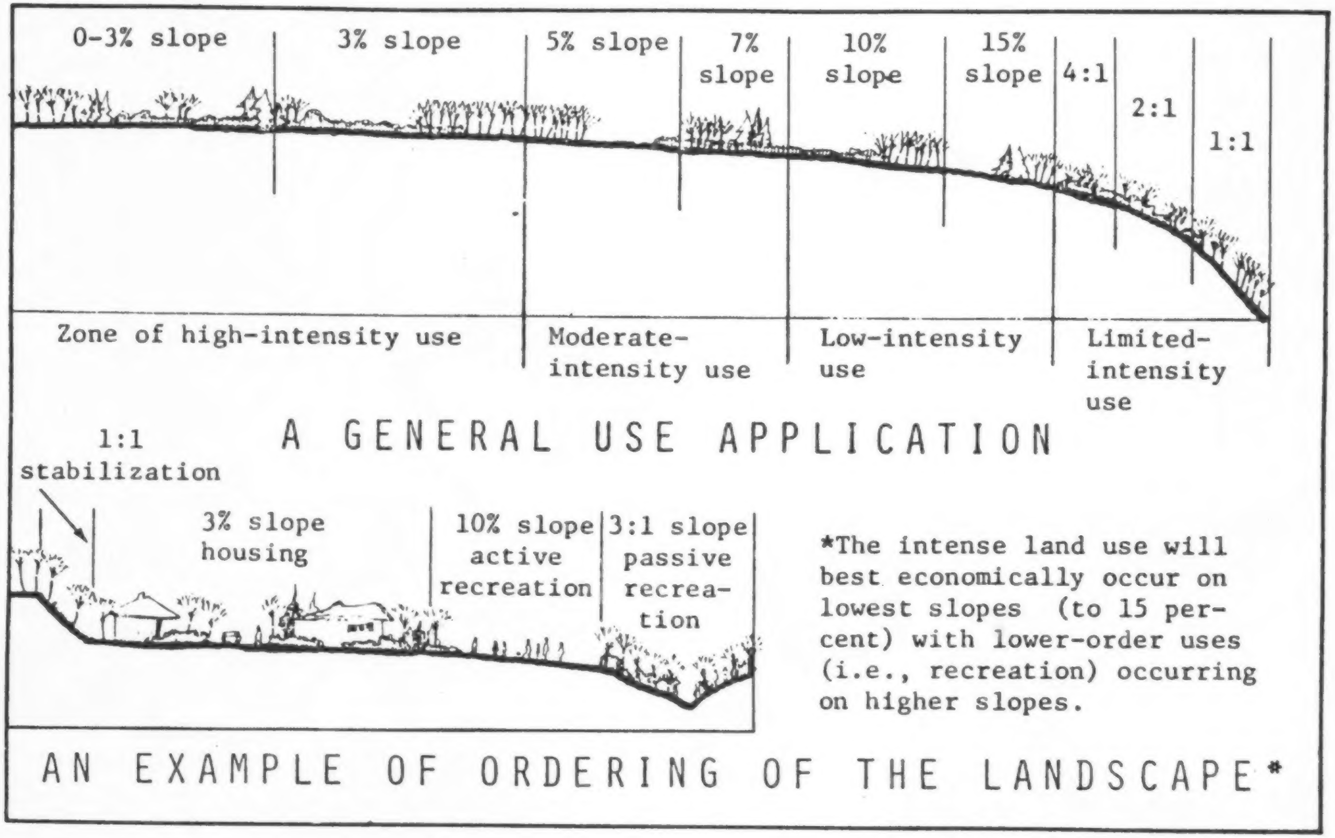
0-3% slope
3% slope
5% slope
7% slope
10% slope
15% slope
4:1
2:1
1:1
Zone of high-intensity use
Moderate-intensity use
Low-intensity use
Limited-intensity use
A GENERAL USE APPLICATION
1:1 stabilization
3% slope housing
10% slope active recreation
3:1 slope passive recreation
*The intense land use will best economically occur on lowest slopes (to 15 percent) with lower-order uses (i.e., recreation) occurring on higher slopes.
AN EXAMPLE OF ORDERING OF THE LANDSCAPE*

Figure 15. Relative ordering of land use referenced to slope (Jensen, 1967).

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USDA Slope Classification--

The slope classification of the U.S. Department of Agriculture (Table 11) was developed for agricultural soils mapping purposes and is applicable throughout the United States. Recognizing that one single classification would not be suitable to the slope characteristics of all areas, their recommendations are presented as broadly defined class limits.

Slope Analysis (Rubenstein, 1968)--

A slope analysis aids in recognizing areas on the site that lend themselves to building locations, roads, parking, or play areas. It may also show if construction is feasible. A parking lot, for example, should have a grade of under 5 percent. If there is no land available that meets this requirement, regrading will be necessary. The cost of grading may determine whether or not the development of a site is feasible.

A typical breakdown of grades would be 0 to 5 percent, 5 to 8 percent, 8 to 10 percent, 10 to 15 percent, 15 to 20 percent, 20 to 25 percent, and over 25 percent. These grades are established by measuring the distance between contours at a given scale and contour interval. The formula is $D = \frac{\text{contour interval}}{\%\text{ grade}} \times 100$, where D is the distance between contours at a particular grade to be set. In order to set a 5 percent grade at a contour interval of 2 ft the equation would be

$$D = \frac{\text{contour interval} \times 100}{\%\text{ grade}}$$

$$D = \frac{2\text{ ft}}{5\%} \times 100$$

$$D = 40\text{ ft}$$

TABLE 11. USDA SLOPE CLASSIFICATION

Slope description	Slope (percent) Lower limit	Slope (percent) Upper limit
Level	0	1 - 3
Gently sloping	1 - 3	5 - 8
Sloping	5 - 8	10 - 16
Moderately steep	10 - 16	20 - 30
Steep	20 - 30	45 - 65
Very steep	45 - 65	none

The over all pattern of slopes will emerge through slope analysis. Awareness of this pattern helps the site planner determine the best land uses for various portions of the site, along with feasibility of construction.

EXPOSURE (Toumey and Korstian, 1947)

Exposure refers to the direction of the slope of the land according to the points of the compass. The exposure of a slope determines the amount of sunlight received by a site. The sunlight, in turn, modifies the moisture content and the temperature of the soil and air. A poleward slope is considerably moister and cooler than one on the equator side of a mountain.

Exposure influences plant growth chiefly through its effect upon temperature and soil water. Thus a slope exposed to the sun and wind often bears a different vegetation from one less exposed to either. Great differences may exist in temperature and atmospheric humidity on different exposures only short distances away.

DRAINAGE

Analysis and evaluation of the existing drainage system is essential when site suitability for various land use types is determined and when environmental impact on that particular site is estimated. Drainage is controlled almost entirely by the physical character and altitude of surface features. Analysis of drainage systems helps to understand the dip and strike of the basic bed rock structure and the fault and fracture patterns that exist in it. Analysis also shows the resistance of the soil (and of the rock material) to weathering and erosion.

To properly define the existing drainage system for a given site requires that the following tasks be performed (Stranberg, 1967):

1. Stream course delineation,
2. Drainage and sub-drainage basin delineation,
3. Drainage pattern and form analysis,
4. Drainage texture analysis, and
5. Slope and landform analysis.

A brief review of the methods used to perform these tasks is included in Volume 3 of this series.

Land uses, other than forestry or passive recreation, generally require modification of the natural or existing drainage system. Urban land uses normally require that provisions be made to intercept and dispose of surface water flow by using an elaborate arrangement of storm drainage structures. Agricultural land uses may also require that excessive surface flows be removed from the land surface, either by using drainage ditches or a system of buried drain pipes. Frequently the need also arises to lower the groundwater table below the root zone to improve plant growth or reduce the accumulation of soil salts.

The surface mining process can completely alter existing drainage patterns at the site. At the same time, however, it provides an excellent opportunity to restructure the drainage system of the site to suit almost any desired end use. The key to a successful conversion from a premining to a postmining drainage system lies in a thorough evaluation of the basic drainage elements. The analytical methods discussed in Volumes 3 and 4, Geology of Eastern Coalfields and Mine Hydrology, should serve as a guide to the mine planner in making this evaluation. Figure 16 illustrates the manner in which a hydrographic map for a small site can be presented. Figures 17 and 18 show the differences in a surface drainage system that can result from a mining operation (Keefer and Hadley, 1976).

EFFECTS OF MINING ON GEOMORPHIC FACTORS

Surface coal mining operations can and often do have a direct effect on topography, relief, slope, and drainage but generally have little if any influence on altitude and exposure. The effect of surface coal mining operations on topography, relief, and slope is closely related to both the existing topography and the mining method employed. The greatest impact of mining operations on topography and slope is evidenced in the Appalachian region because of the nature of the rugged terrain and the use of contour and mountaintop removal operations. In contrast, operations in the interior basin are conducted on relatively flat to gently undulating terrain that facilitates restoration of the mined area back to original contour. The major exception to the practice of restoring lands whenever possible results from the commonly employed practice of converting the last cut to a water body.

The most significant effect of surface coal mining operations involves the various elements that together constitute the drainage system. Surface mining operations involve the complete restructuring of the surficial and bed rock geology down to and slightly below the coal seam. The blasting and fragmentation of the consolidated strata and the spoiling sequence employed can result in substantial changes in numerous elements of the drainage systems. The elemental changes generally include changes in the infiltration capacity of the surface soil and in permeability, porosity, and conductivity of the subsoil and bed rock materials, and important changes in the geochemical processes at work in these materials. Variations in the characteristics of these fundamental properties as previously detailed can result in marked changes in drainage patterns, watershed boundaries, availability of water supplies, etc. Volume 4 of this series of reports, Mine Hydrology, examines this particular aspect in great detail, and the reader interested in the quantitative and qualitative hydrologic considerations associated with surface coal mining operations is referred to that report.

SUMMARY

A brief review of the major geomorphic factors and their influence on the suitability for various land use types has been presented. Table 12 provides a summary of the relative importance of the five factors discussed in determining the suitability of a parcel of land for supporting various land

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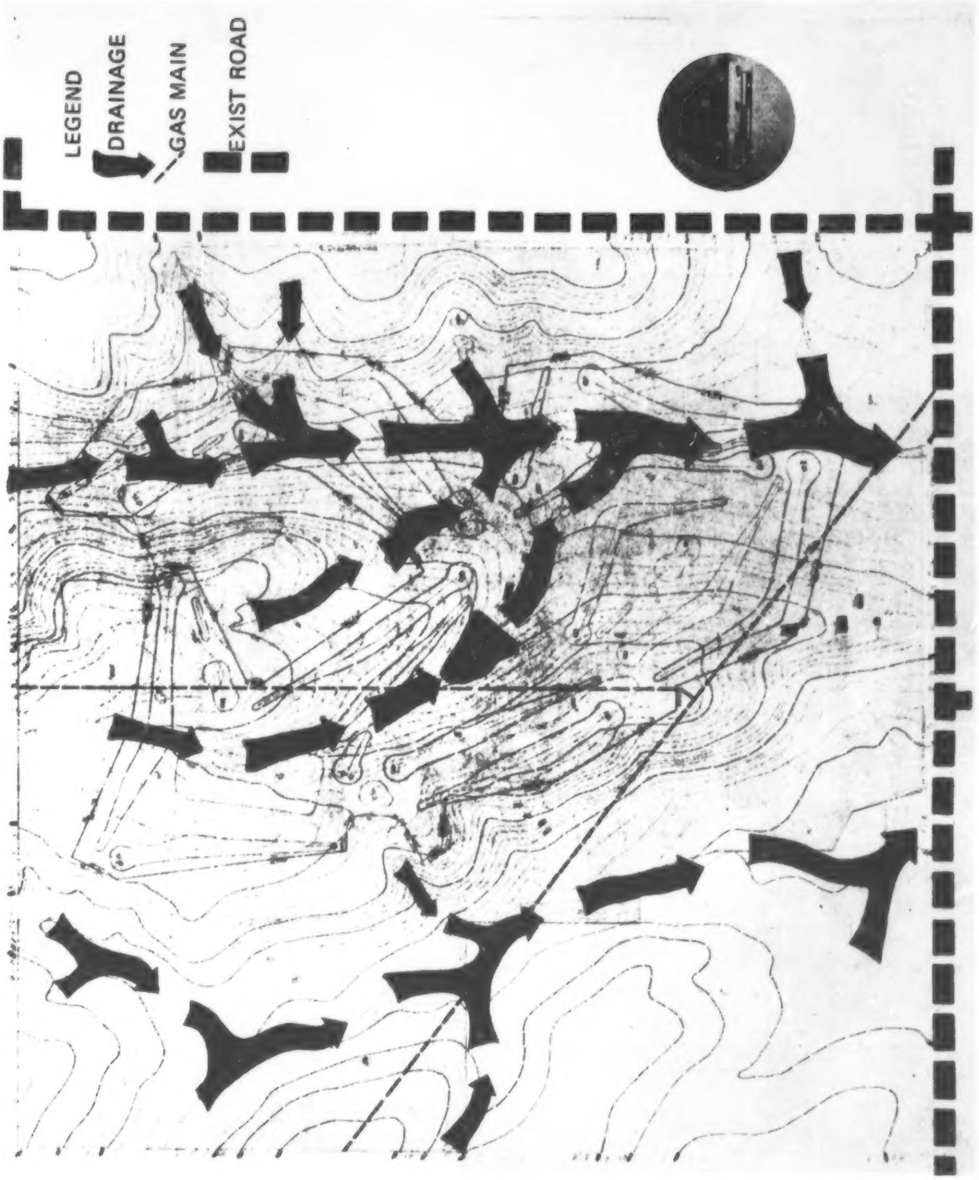
LEGEND
DRAINAGE
GAS MAIN
EXIST ROAD

Figure 16. Example hydrographic map (Rubenstein, 1968).

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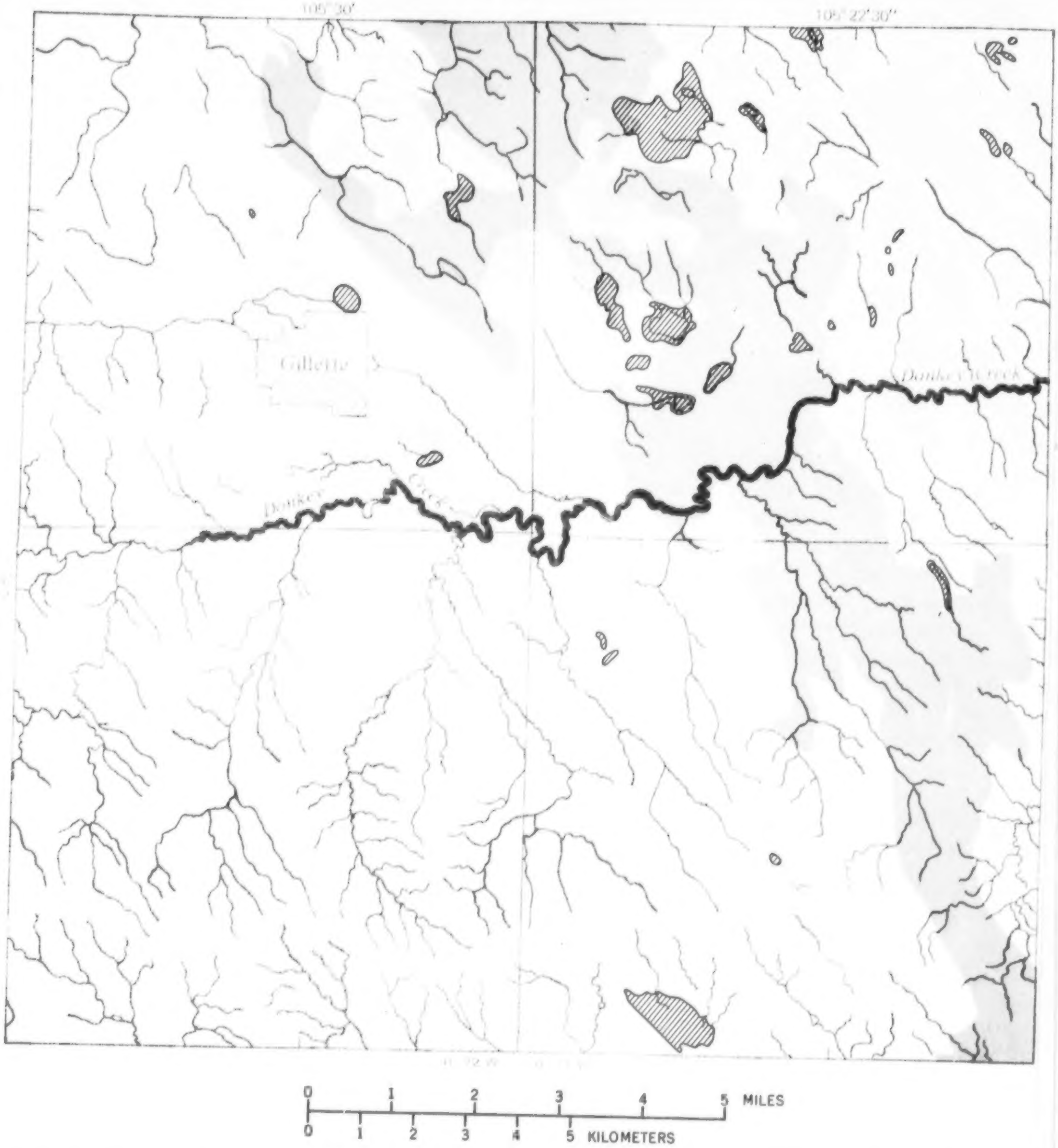

105°30'
105°22'30"
Gillette
Donkey Creek
Donkey Creek
0 1 2 3 4 5 MILES
0 1 2 3 4 5 KILOMETERS

Figure 17. Present surface drainage, Gillette and vicinity. Closed topographic depressions shown by patterned areas. Strippable coal zone, Wyodak-Anderson coal deposit, shown by shaded area. All drainage is intermittent except part of Donkey Creek, shown as heavy line (Keefer and Hadley, 1976).

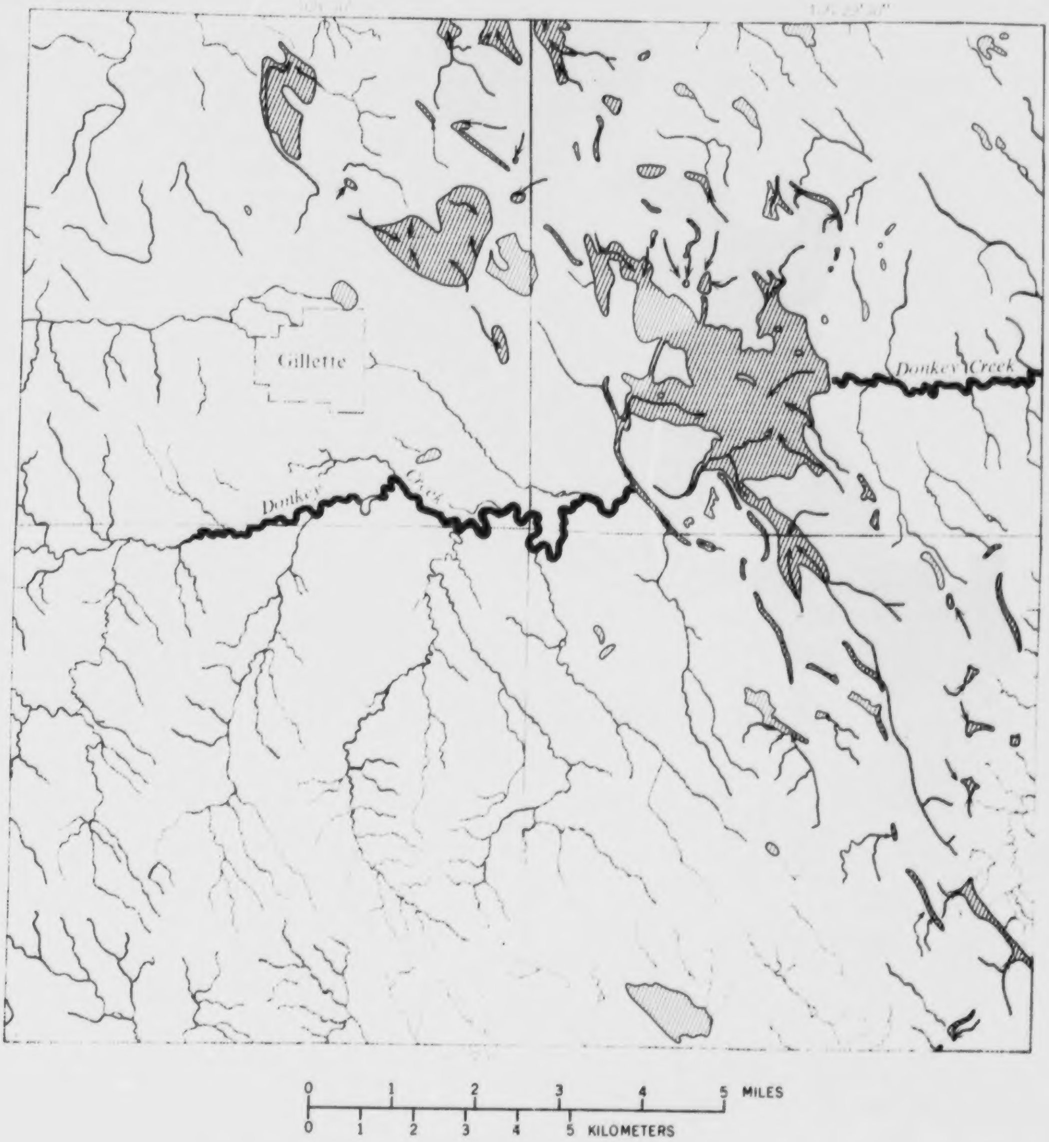

Gillette
Donkey Creek
Donkey Creek
0 1 2 3 4 5 MILES
0 1 2 3 4 5 KILOMETERS

Figure 18. Reconstructed surface drainage, Gillette and vicinity, assuming all coal is extracted from the strippable zone of the Wyodak-Anderson deposit (Keefer and Hadley, 1976).

use types. The two most important geomorphic factors are slope and drainage. Gentle slopes enable the development of high intensity land uses such as institutional, commercial, or residential developments. Steep slopes usually lead to low intensity land uses and are more suited for forestry and wildlife developments. Adequate water resources and good drainage systems are essential for most land use development plans. Since mining can significantly affect drainage patterns, both in terms of quantity and quality of the water resources, this is an area where considerable effort must be done before determining a postmining land use.

Additional discussion of the relationship among geographic factors and the various land use types is provided later in this report under the discussion of site considerations for the various land use types.

TABLE 12. RELATIVE IMPORTANCE OF GEOMORPHIC FACTORS AS DETERMINANTS OF LAND USE SUITABILITY

Land use types	Geomorphic factors				
	Topography	Slope	Drainage	Altitude	Exposure
Forestry and wildlife	2*	1	1	2	2
Recreational	3	3	3	3	3
Agricultural	1	1	1	2	2
Residential	2	2	1	3	3
Institutional	2	1	1	3	3
Commercial	2	1	1	3	3
Industrial	2	1	1	3	3

* 1 = Factor has high degree of influence on suitability of site for that particular land use.
2 = Factor has moderate degree of influence.
3 = Factor has low degree of influence.

SECTION 7

SOIL FACTORS

OVERVIEW

Quantitative knowledge of the soil and subsoil properties is necessary to evaluate the land use suitability of a given parcel of land. An extensive amount of information has been developed about soils and subsoils. This present body of knowledge has resulted from numerous investigations by individuals in varied disciplines, including agronomy, soil science, geology, and engineering, among others. Each of these groups views the soil and subsoil characteristics from a different viewpoint and with a different end use in mind.

The soil factors refer to soil and subsoil conditions. Many people are unaware that great differences in soil properties occur even within short distances. Soils may be seasonably wet or subject to flooding. They may be shallow to bedrock. They may be too unstable to be used as a foundation for buildings or roads. Very clayey or wet soils are poorly suited to septic tank absorption fields, and a high water table makes a soil poorly suited to basements or underground installations.

THE SOIL PROFILE

An examination of soil and subsoil can begin with a description of the soil profile, a vertical cross-sectional view exposed in an excavation or cut, extending from the surface of the earth down to bedrock (Buckman and Brady, 1972). Figure 19 shows two such views that contain some of the principal components of the soil profile. The regolith, the layer of unconsolidated materials extending from the earth's surface to bedrock, can exhibit considerable variation. It may be negligibly shallow or hundreds of feet thick; it may consist of material weathered from the underlying rock, or it may have been transported by the action of wind, water, or ice and deposited on the bedrock (Buckman and Brady, 1972).

The regolith can be subdivided further into the surface soil, the subsoil, and the substratum. The agronomist is principally concerned with the surface soil, which contains the majority of organic soil, and its ability to support plant life. The engineer is primarily interested in the subsoil and substratum, largely inorganic, and their ability to support loads in structures (Buckman and Brady, 1972).

Exhaustive study and analysis by the U.S. Department of Agriculture have resulted in classification of the soil profile into a series of soil horizons (USDA, 1951). A soil horizon is the layer of soil approximately parallel to the soil surface with characteristics produced by the soil-forming processes. One soil horizon is commonly differentiated from an adjacent one at least partly on the basis of characteristics that can be seen in the field. Figure 20 presents a hypothetical soil profile with all the principal horizons. No one soil has all the various kinds of horizons in it. The simple drawings in Figure 21 present a few examples of how the horizons of actual profiles may be usefully designated. A thorough description of the USDA soil horizon designations is provided in Appendix A.

SOIL CLASSIFICATION (Buckman and Brady, 1972)

A wide variety in type of soils can be found throughout the United States. Figure 22 is a general soil map of the United States that provides a classification of dominant orders and suborders. This classification, developed by the U.S. Department of Agriculture, provides basic physical and chemical data for later interpretations of soil suitability for a variety of uses.

Orders and Suborders

In the present soil classification system, nine orders are recognized. The differentiae of the orders tend to produce a broad climatic grouping of soils. However, two of the orders, the entisols and the histosols (organic soils), can be found under almost every climatic condition. The orders, almost all-inclusive, and their sub-orders are further divided into great groups, subgroups, families, series, and types.

Great Groups

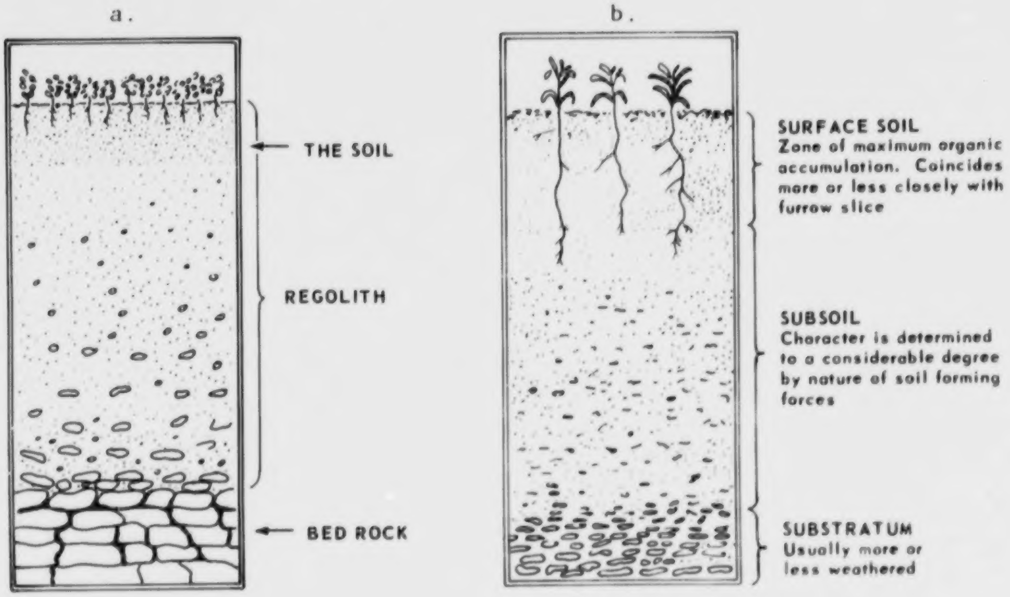
Each great group is defined, within its respective suborder, largely by the presence or absence of uniform diagnostic horizons and the arrangement of those horizons. The great groups may be considered segments of the continuum of soils, spaced with nearly equal uniformity.

Subgroups

Soil subgroups are subdivisions of great groups and can be defined only in reference to the great groups. If we think of a great group as occupying a segment of a soil-properties spectrum, the core, or central area, is a subgroup.

Families

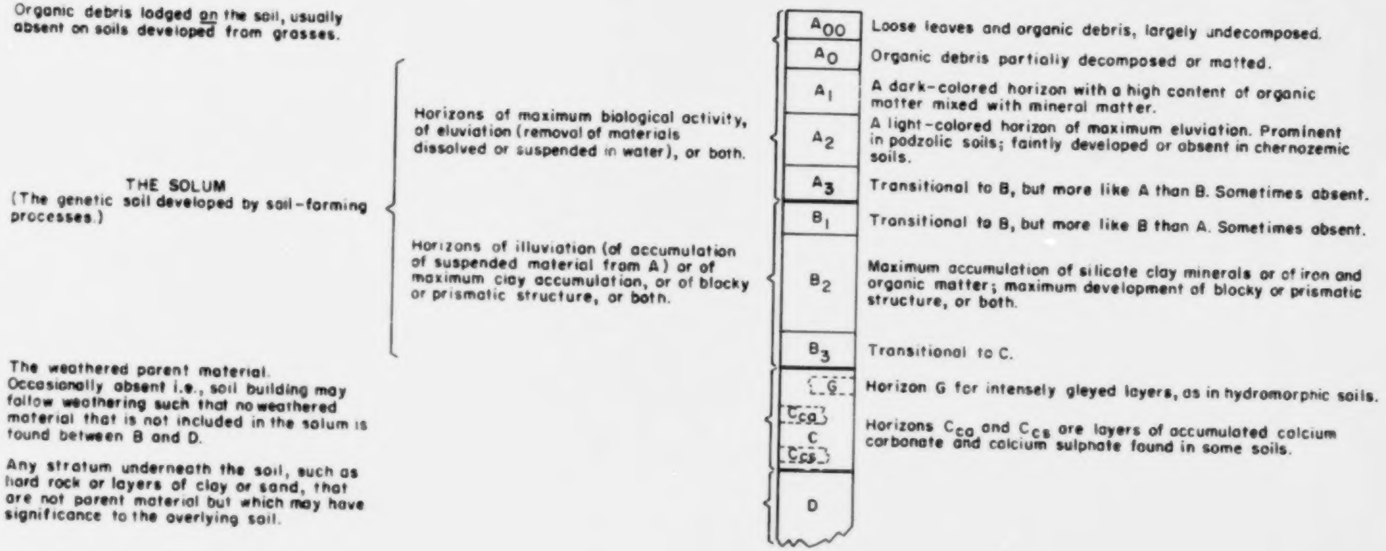
Soil families are differentiated within a subgroup primarily on the basis of properties important to the growth of plants. The families are rather homogeneous with respect to soil-air-root relationships and their capacities to supply the major nutritive elements other than nitrogen. The differentiae


a.
b.
THE SOIL
REGOLITH
BED ROCK
SURFACE SOIL
Zone of maximum organic accumulation. Coincides more or less closely with furrow slice
SUBSOIL
Character is determined to a considerable degree by nature of soil forming forces
SUBSTRATUM
Usually more or less weathered

a. The relative positions of the regolith, its soil, and the underlying country rock. Sometimes the regolith is so thin that it has been changed entirely to soil which, in such a case, rests directly on bed rock (Buckman and Brady, 1972).

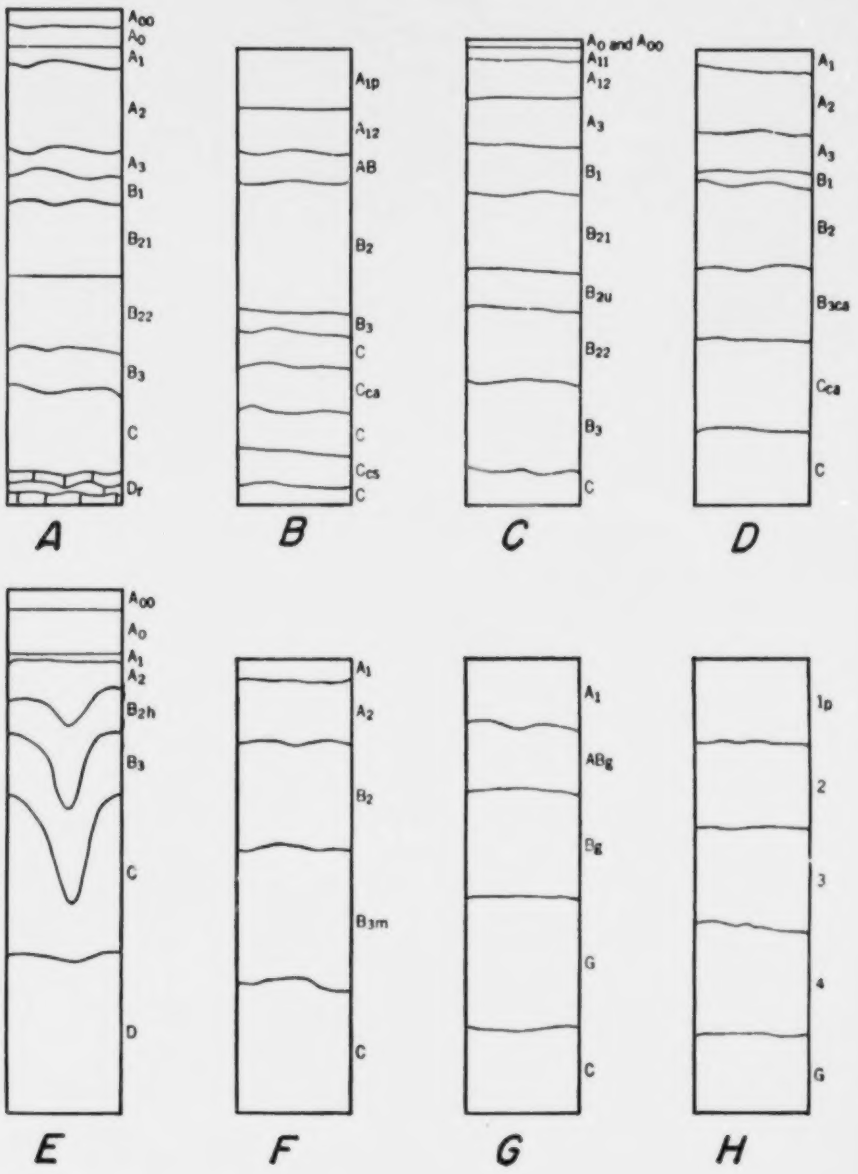
b. A representative soil profile. The surface horizons are relatively high in organic matter and become the furrow-slice when the land is plowed. The subsoil, while markedly weathered, usually contains little organic matter. At variable depths it merges more or less gradually into the substratum (parent material). All of the layers above the substratum are spoken of collectively as the solum (Buckman and Brady, 1972).

Figure 19. Principal components of the soil profile.


Organic debris lodged on the soil, usually absent on soils developed from grasses.
THE SOLUM
(The genetic soil developed by soil-forming processes.)
The weathered parent material. Occasionally absent i.e., soil building may follow weathering such that no weathered material that is not included in the solum is found between B and D.
Any stratum underneath the soil, such as hard rock or layers of clay or sand, that are not parent material but which may have significance to the overlying soil.
Horizons of maximum biological activity, of eluviation (removal of materials dissolved or suspended in water), or both.
Horizons of illuviation (of accumulation of suspended material from A) or of maximum clay accumulation, or of blocky or prismatic structure, or both.
A_{00}
A_0
A_1
A_2
A_3
B_1
B_2
B_3
G
C_{ca}
C
C_{cs}
D
Loose leaves and organic debris, largely undecomposed.
Organic debris partially decomposed or matted.
A dark-colored horizon with a high content of organic matter mixed with mineral matter.
A light-colored horizon of maximum eluviation. Prominent in podzolic soils; faintly developed or absent in chernozemic soils.
Transitional to B, but more like A than B. Sometimes absent.
Transitional to B, but more like B than A. Sometimes absent.
Maximum accumulation of silicate clay minerals or of iron and organic matter; maximum development of blocky or prismatic structure, or both.
Transitional to C.
Horizon G for intensely gleyed layers, as in hydromorphic soils.
Horizons C_{ca} and C_{cs} are layers of accumulated calcium carbonate and calcium sulphate found in some soils.

Horizon B may or may not have an accumulation of clay. Horizons designated as C_{ca} usually appear between B_3 and C. The G may appear directly beneath the A.

Figure 20. A hypothetical soil profile having all the principal horizons (USDA, 1951).


A00
A0
A1
A2
A3
B1
B21
B22
B3
C
Dr
A
A1p
A12
AB
B2
B3
C
Cca
C
Ccs
C
B
A0 and A00
A11
A12
A3
B1
B21
B2u
B22
B3
C
C
A1
A2
A3
B1
B2
B3ca
Cca
C
D
A00
A0
A1
A2
B2h
B3
C
D
E
A1
A2
B2
B3m
C
F
A1
ABg
Bg
G
C
G
1p
2
3
4
G
H

A = gray-brown podzolic; B = chernozem (cultivated); C = latosol; D = solodized-solonetz; E = podzol; F = planosol; G = humic gley (wiesenboden); H = bog.

Figure 21. Hypothetical profiles to illustrate a few horizon designations (USDA, 1951). Note: For a complete description of soil horizon designations refer to Appendix A.

are based on the solum below the plow layer, or an equivalent depth in soils lacking genetic sola. Differentiae include texture, thickness of horizons, mineralogy, reaction, consistence, and permeability.

Series

A soil series is a collection of soil individuals, essentially uniform in characteristics, and arrangement of horizons. If genetic horizons are thin or absent, a series is a collection of soil individuals that, within defined depth limits, are uniform in all soil properties diagnostic for the series. The properties should have relevance to soil genesis, to plant growth, and to engineering uses.

Types

The soil type is the smallest unit in the natural classification of soils. A soil series is constituted of one type or a few types. These are the common classification units seen on soil maps and survey reports.

SOIL PROPERTIES FOR AGRICULTURAL USES

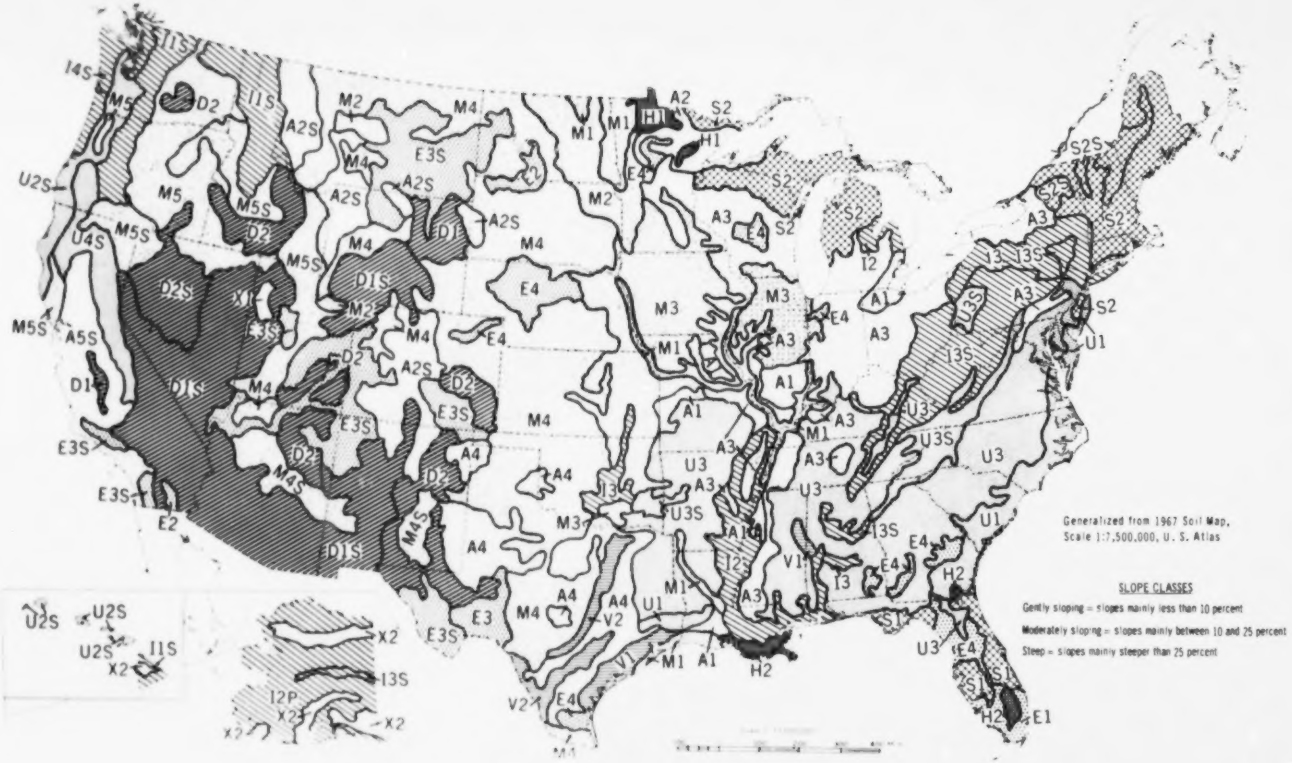
Soils provide, in the natural state or after treatment, certain favorable conditions for plant growth. Soil not only furnishes a stratum for germination of seed as well as spread and anchorage of the plant roots but also maintains a reasonably satisfactory balance of soil moisture and essential mineral elements for plant nutrition.

The type and condition of soil are important when determining which crops to raise. Some of the major and most commonly used indicators of soil characteristics include:

1. Texture,
2. Structure,
3. Organic matter content,
4. Moisture content,
5. Permeability,
6. pH,
7. Depth to bedrock, and
8. Color of surface soil.

Texture

Soil texture refers to the sizes and proportions of various particles making up a particular soil. From largest to smallest, these soil textural classes are sands, silts, and clays. The various sizes of soil particles and soil textural class names are provided in Tables 13 and 14. Figure 23, the soil textural triangle, relates the class name of a soil to its particle size distribution. A point corresponding to certain percentages of silt, clay, and sand is found by first locating the point that represents one of these percentages on the appropriate base. The line is then drawn through this point which is parallel to the base of the triangle that symbolizes 0 percent


I4S
I1S
M5
D2
I1S
A2S
M2
M4
E3S
M1
M1
H1
A2
S2
H1
E4
U2S
M5
M4
A2S
A2S
M2
A3
E4
S2
S2
S2S
S2S
A3
S2
U4S
M5S
M5S
D2
D1
A2S
M4
I2
A1
I3
I3S
D2S
X1
M5S
M4
D1S
E4
M3
E4
A3
U3S
A3
S2
M5S
A5S
M2
E3S
E4
M3
A3
I3S
U1
D1
D1S
M4
D2
A2S
D2
E3S
M1
A1
A1
U3
M4
M1
A3
U3S
E3S
E3S
D2
A4
A4
A4
U3
A3
A3
U3S
U3
E3S
D2
M4S
I3
M3
U3S
A1
U3
I3S
E4
U1
E2
D1S
M4S
A4
M4
A4
V2
U1
M1
I2
A3
V1
I3
E4
H2
U2S
U2S
U2S
X2
I1S
E3
E3S
V1
M1
A1
H2
S1
U3
E4
X2
I3S
I2P
X2
X2
X2
V2
E4
S1
S1
H2
E1

Generalized from 1967 Soil Map,
Scale 1:7,500,000, U. S. Atlas

SLOPE CLASSES

Gently sloping = slopes mainly less than 10 percent

Moderately sloping = slopes mainly between 10 and 25 percent

Steep = slopes mainly steeper than 25 percent

Figure 22. General soil map of the United States. Classification of dominant orders and suborders of the new classification system of soils (see legend) (Buckman and Brady, 1972).

LEGEND FOR FIGURE 26

SOIL ORDERS AND SUBORDERS OF THE UNITED STATES

☐ **ALFISOLS** . . . Soils with gray to brown surface horizons, medium to high base supply, and subsurface horizons of clay accumulation; usually moist but may be dry during warm season

- **A1** AQUALFS (gently sloping)
- **A2** BORALFS (gently sloping)
- **A2S** BORALFS (steep)
- **A3** UDALFS (gently or moderately sloping)
- **A4** USTALFS (gently or moderately sloping)
- **A5S** XERALFS (gently sloping to steep)

▨ **ARIDISOLS** . . . Soils with pedogenic horizons, low in organic matter, and dry more than 6 months of the year in all horizons

- **D1** ARGIDS (gently or moderately sloping)
- **D1S** ARGIDS (gently sloping to steep)
- **D2** ORTHIDS (gently or moderately sloping)
- **D2S** ORTHIDS (gently sloping to steep)

░ **ENTISOLS** . . . Soils without pedogenic horizons

- **E1** AQUENTS (gently sloping)
- **E2** ORTHENTS (gently to moderately slopping) deep to hard rock
- **E3** ORTHENTS (gently to moderately sloping) shallow to hard rock
- **E3S** ORTHENTS (steep) shallow to hard rock
- **E4** PSAMMENTS (gently to moderately sloping)

░ HISTOSOLS . . . Organic soils

- H1 FIBRISTS fibrous or woody peats, largely undecomposed
- H2 SAPRISTS decomposed mucks

▨ INCEPTISOLS . . . Soils that are usually moist, with pedogenic horizons of alteration of parent materials but not of accumulation

- I1S ANDEPTS (gently sloping to steep)
- I2 AQUEPTS (gently sloping)
- I2P AQUEPTS (gently sloping to steep) continuous or sporadic permafrost
- I3 OCHREPTS (gently to moderately sloping)
- I3S OCHREPTS (gently sloping to steep)
- I4S UMBREPTS (moderately sloping to steep)

☐ MOLLISOLS . . . Soils with nearly black, organic-rich surface horizons and high base supply

- M1 AQUOLLS (gently sloping)
- M2 BOROLLS (gently or moderately sloping)
- M3 UDOLLS (gently or moderately sloping)
- M4 USTOLLS (gently to moderately sloping)
- M4S USTOLLS (moderately sloping to steep)
- M5 XEROLLS (gently to moderately sloping)
- M5S XEROLLS (moderately sloping to steep)

░ SPODOSOLS . . . Soils with accumulations of amorphous materials in subsurface horizons

- S1 AQUODS (gently sloping)
- S2 ORTHODS (gently to moderately sloping)
- S2S ORTHODS (steep)

☐ ULTISOLS . . . Soils that are usually moist with horizon of clay accumulation and a low base supply

- U1 AQUULTS (gently sloping)
- U2S HUMULTS (moderately sloping to steep)
- U3 UDULTS (gently to moderately sloping)
- U3S UDULTS (moderately sloping to steep)
- U4S XERULTS

░ VERTISOLS . . . Soils with high content of swelling clays and wide deep cracks at some season

- V1 UDERTS (gently sloping) cracks open for only short periods, less than 3 months in a year
- V2 USTERTS cracks open and close twice a year and remain open more than 3 months

☐ AREAS with little soil . . .

- X1 Salt flats
- X2 Rockland, ice fields

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TABLE 13. SIZE LIMITS OF SOIL SEPARATES (USDA, 1951)

Name of separate	Diameter (range): mm
Very coarse sand*	2.0 - 1.0
Coarse sand	1.0 - 0.5
Medium sand	0.5 - 0.25
Fine sand	0.25 - 0.10
Very fine sand	0.10 - 0.05
Silt	0.05 - 0.002
Clay	Below 0.002

* Prior to 1947 this separate was called fine gravel. Now fine gravel is used for coarse fragments from 2 mm to 1.27 cm in diameter.

TABLE 14. SOIL TEXTURAL CLASSES (USDA, 1951)

First grouping	Second grouping	Basic soil textural class names
(I) Sandy soil	(1) Coarse-textured soil	Sand Loamy sand
(II) Loamy soil	(2) Moderately coarse-textured soil	Sandy loam Fine sandy loam
	(3) Medium-textured soil	Very fine sandy loam Loam Silt loam Silt
	(4) Moderately fine-textured soil	Clay loam Sandy clay loam Silty clay loam
(III) Clayey soil	(5) Fine-textured soil	Sandy clay Silty clay Clay

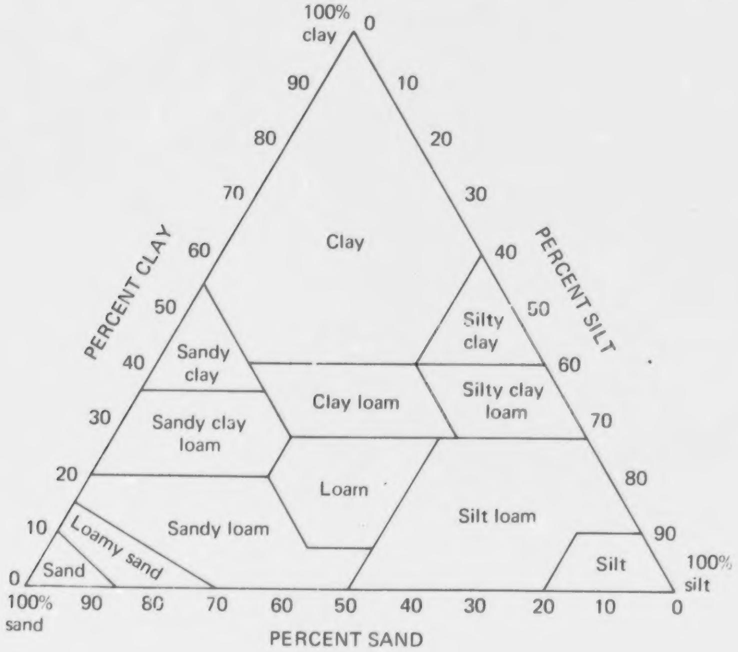
100% clay
0
10
20
30
40
50
60
70
80
90
PERCENT CLAY
PERCENT SILT
Clay
Silty clay
Sandy clay
Clay loam
Silty clay loam
Sandy clay loam
Loam
Silt loam
Sandy loam
Loamy sand
Sand
Silt
100% silt
100% sand
PERCENT SAND

Figure 23. Soil textural triangle (Buckman and Brady, 1972).

for that particular component of the mixture. This yields a line segment within the boundaries of the triangle which represents all points in the triangle that correspond to that particular percentage of that component. Following this same procedure with one of the other two percentages gives one point of intersection, which is automatically correct with respect to the third component percentage. The point of intersection is located within an area bearing the class name of the soil in question.

Structure

Soil structure is the arrangement of particles into groups. Structure is strictly a field term that describes the gross, overall aggregation or arrangement of the primary soil separates. A soil profile may be dominated by a single structural pattern; more commonly, a number of types of aggregation are encountered from one horizon to the next. Soil structure has a strong influence on a number of soil conditions, such as water movement, heat transfer, aeration, bulk density, and porosity.

Four primary types of soil structure are recognized: platy, prismlike, blocklike, and spheroidal. A brief description of each of these structural types with schematic drawings is presented in Figure 24.

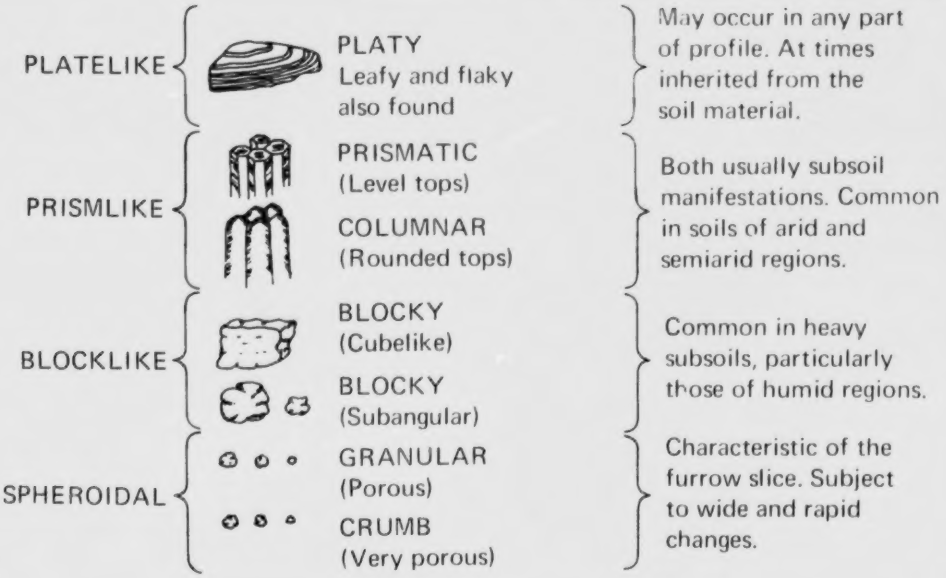
PLATELIKE
PLATY
Leafy and flaky also found
May occur in any part of profile. At times inherited from the soil material.
PRISMLIKE
PRISMATIC
(Level tops)
COLUMNAR
(Rounded tops)
Both usually subsoil manifestations. Common in soils of arid and semiarid regions.
BLOCKLIKE
BLOCKY
(Cubelike)
BLOCKY
(Subangular)
Common in heavy subsoils, particularly those of humid regions.
SPHEROIDAL
GRANULAR
(Porous)
CRUMB
(Very porous)
Characteristic of the furrow slice. Subject to wide and rapid changes.

Figure 24. Various structural types found in mineral soils (Buckman and Brady, 1972).

Organic Matter Content

Organic matter is plant and animal residue in various stages of decomposition. The organic matter content of a soil is small--only about 3 to 5 percent by weight in a representative mineral topsoil. Organic matter functions as a granulator of the mineral particles and is largely responsible for the loose, easily managed condition of productive soils. It is also a major source of two important mineral elements, phosphorus and sulfur, and essentially the sole source of nitrogen. The amount of water a soil can hold and the proportion of this water available for plant growth are increased by the effect of organic matter on the physical condition of the soil. Finally, organic matter is the main source of energy for soil microorganisms, without which biochemical activity would come practically to a standstill.

Moisture Content

The moisture content of a surface soil is a reflection of its moisture-holding capacity. The ability of a soil to hold water depends on its texture, permeability, depth, and organic matter content and is often referred to as the field capacity of the soil. The field capacity of soils--i.e., the amount of water held against the force of gravity--usually ranges from 1 to 2 in. in each foot of soil. The finer the soil particles, the more water the soil holds. Figure 25 gives the field capacity of three common soil types with soil moisture contents at different tension and wilting points. Extremely coarse, sandy soils are unable to store moisture in sufficient quantities for crop growth. In general, soils that are able to hold large quantities of

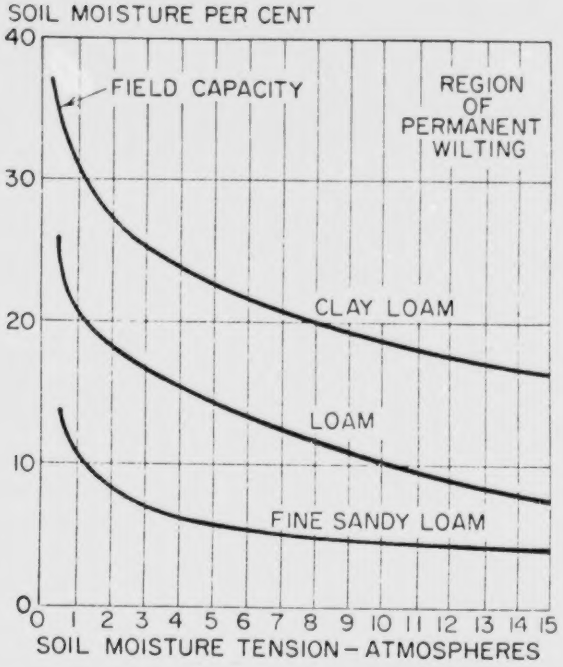

Figure 25. Field capacity of three soil types with soil moisture contents at different tension and wilting points (Martin et al., 1976).

water are desirable for plant growing. However, some clays with excessive moisture-holding capacity can present a problem.

Permeability

The permeability of a soil is its ability to allow water and air to move through it. The texture and structure of soils are the properties that have the most influence on permeability. Sandy soils generally have higher permeability than finer-textured soils. Likewise, soils with stable granular structure conduct water much more rapidly than do those with unstable structural units since such soils break down upon being wetted. Fine clay and silt can clog the small connecting channels of even the larger pores. Fine-textured soils that crack during dry weather at first allow rapid water movement. Later, these cracks swell shut, thereby reducing water movement to a minimum. Organic matter in the soil helps to maintain a high proportion of macropores and thus increases permeability.

pH

The chemical reaction of a soil--that is, whether it is acid, neutral, or alkaline--is another important soil property. Figure 26 shows the ranges of soil pH encountered as well as the relationship between pH values and terms commonly used to describe soil reaction.

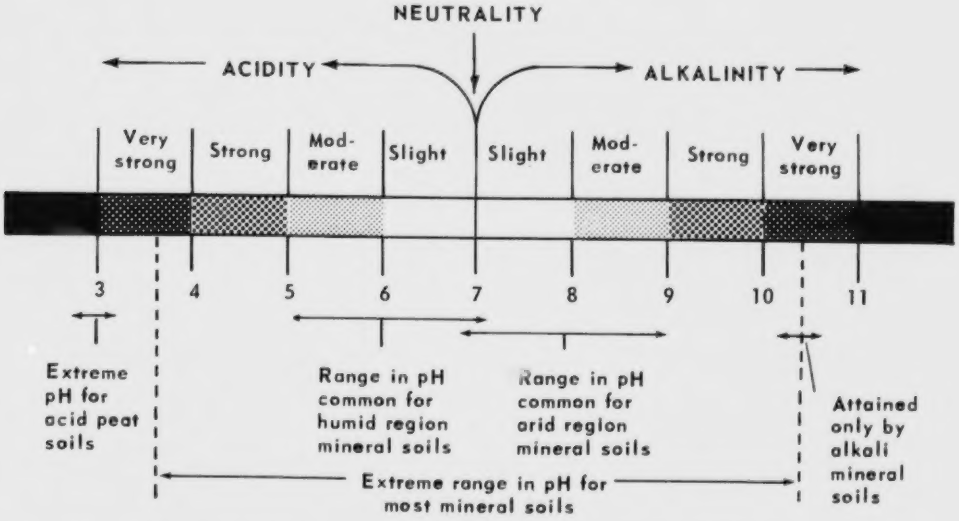
NEUTRALITY
ACIDITY
ALKALINITY
Very strong
Strong
Mod-erate
Slight
Slight
Mod-erate
Strong
Very strong
3
4
5
6
7
8
9
10
11
Extreme pH for acid peat soils
Range in pH common for humid region mineral soils
Range in pH common for arid region mineral soils
Attained only by alkali mineral soils
Extreme range in pH for most mineral soils

Figure 26. Extreme range in pH for most mineral soils and the ranges commonly found in humid region and arid region soils (Brady, 1974).

The soil pH may influence nutrient absorption and plant growth in two ways: (a) through the direct effect of the hydrogen ion, or (b) indirectly through its influence on nutrient availability and the presence of toxic ions. High acidity may complicate the growth of crop plants by increasing absorption of aluminum and manganese by the plants and retarding absorption of calcium or phosphorous. Excessive alkalinity may also interfere with absorption of phosphorous or other ions.

Depth to Bedrock

The depth of the surface soil and subsoil is another important soil property. Deep soils allow roots to reach more soil moisture and plant nutrients than shallow soils with underlying hardpan, rock, or gravel that may interfere with root development. A further disadvantage of shallow soils is leveling for irrigation may be impractical. Measurements used for depth of soil include the following:

Deep	36 inches or more
Moderately deep . .	20 to 36 inches
Shallow	10 to 20 inches
Very shallow	less than 10 inches

Color of Surface Soil

Although it is not a functional characteristic, the color of a soil is of great value as an indirect measure of other more important characteristics or qualities that are not so easily and accurately observed. Since it is an indirect measure, color is often used in conjunction with other characteristics, such as soil texture. Color can be used as an indicator of organic matter, drainage characteristics, and age of soils.

Three major soil color classes are generally used. They are: (1) dark, (2) medium, and (3) light (USDA, 1951).

Dark-colored soils include those that are black and dark brown. They are usually high in organic matter and fertility. Not all such soils are fertile, however, because some derive their hue from minerals. Excessively dark soils are likely to be found in swampy areas that may need drainage.

Medium-colored soils include those that are dark gray, grayish-brown, and light brown.

Light-colored soils include those that are brownish-gray or light gray. Such soils are frequently low in fertility, though light desert soils may be highly productive when irrigated.

Other soil colors prominent in some areas of the United States are red, dark red, light red, and yellow. These colors are caused by high iron content. Red soils generally have good drainage.

SOIL PROPERTIES FOR ENGINEERING USES

In addition to their uses for agricultural purposes, soils exhibit a wide range of physical and chemical properties that help engineers anticipate soil-related hazards that affect construction of buildings, highways, pipelines, transmission lines, and similar installations. Among the numerous physical and chemical properties of interest, the following are included:

1. Shrink-swell potential,
2. Wetness,
3. Depth to bedrock,
4. Erodibility,
5. Flood hazard,
6. Slope,
7. Bearing capacity,
8. Corrosion potential,
9. Organic layers, and
10. Ease of excavation.

Shrink-Swell Potential

Certain kinds of clay soils expand when wet and shrink when dry, and special foundations are required to compensate for this movement. The site investigation should identify the presence of soils that have large shrink-swell potential.

Wetness

The site investigation should provide data on natural soil drainage, permeability, depth to seasonal water table, and suitability for winter grading for the various soils present at the site. This information can help the engineer anticipate seasonal limitations on the use of heavy machinery for earth moving and compacting and estimate the hazard of flooding or damage to underground structures caused by soil wetness.

Depth to Bedrock

The site investigation should indicate the depth to bedrock and also indicate the kind of bedrock present. The depth of soil cover and bedrock is important when determining land use suitability. Residential subdivision development costs are significantly greater in areas of shallow soil cover than deep soil cover because shallow depths to bedrock cause problems in septic tank design, installation, and maintenance, utility line construction, cellar and foundation excavation, and highway and street location and construction.

Erodibility

The site investigation should provide information on how susceptible each soil is to erosion. Slope is only one factor contributing to erodibility. Other soil properties are also important, especially those properties that determine the cohesiveness of soil particles. These properties commonly vary within different layers of the same soil and cause different degrees of erodibility in different soil layers.

Flood Hazard

The hazards of flooding and ponding should be rated and flood-prone areas should be delineated on the soils map. A strong correlation exists between flood plain soil associations and the historic path of flood waters.

Slope

Slope gradient is a determining factor in establishing the final grade of a construction site and the amount of cut and fill needed to achieve the final grade. Ranges in slope are recorded in soil surveys, and areas where cuts and fills may be needed can be identified by studying soil maps. Slope particularly affects the installation of underground conduits and the construction of roads and highways.

Bearing Capacity

The bearing capacity of soils is closely related to the structural and textural properties of the soils. Soil surveys give estimates of the particle size and plasticity of soils, and each soil layer is classified according to the United and AASHO systems. These classifications help to evaluate soils for shallow foundations and to determine ease of compaction, ease of winter grading, trafficability, density, moisture relationships, susceptibility to frost action, and other properties.

Corrosion Potential

Standard concrete deteriorates rapidly in very acid soils, and steel corrodes in soils that are highly saline or acid. The corrosion potential of each kind of soil should be evaluated during the site investigation.

Organic Layers

Muck and peat are very soft and unstable, and if they are drained, they subside. Areas of organic soils should be clearly delineated on the soil map and the thickness of organic layers should be indicated.

Ease of Excavation

The ease with which soils can be excavated has an important bearing on the costs of the earthmoving operations. Excavating friable soils may cost half as much as excavating soils that are hard and compact. Sticky, clayey soils are difficult to spread in thin layers. Some soils are very susceptible to sloughing in trenches; others are stable. All these properties may differ from layer to layer in the same soil. Data presented in soil surveys can be used by engineers to anticipate earthmoving problems and to prepare more accurate bids for earthmoving.

The many physical properties of soils that relate to engineering problems are presented in a typical county soil survey report.

SOIL SURVEY REPORTS

A good starting point for all soil investigations is the county (or township) soil survey report published and available from the Soil Conservation Service of the U.S. Department of Agriculture. These reports can be used to provide the following information:

1. Potential agricultural uses, including soil capabilities for common cultivated crops, crop yield estimates, woodland suitability groups, and crop adaptation;
2. Wildlife-soil relationships, including capability of different kinds of soil to sustain various food plants and cover for birds and animals common to the area;
3. Non-farm plant material-soil relationships, including suitability of different kinds of soil for lawns, golf courses, playgrounds, parks, and open space reservations;
4. Soil-water relationships by kinds of soil, including identification of areas subject to flooding, stream overflow, ponding, seasonally high water table, and concentrated runoff; and
5. Soil properties influencing engineering uses, including depth to major soil horizons important in construction, liquid limit, plastic

limit, plasticity index, maximum dry density, optimum moisture content, mechanical analysis, AASHO and Unified classifications, percolation rate, bearing strength, shrink-swell ratio, pH, depth to water table, and estimated depth to bedrock if within approximately 20 ft of the ground surface.

These reports can be used in conjunction with soil maps of an area to determine the soil suitability for use as topsoil, sand and gravel, road fill for highway subgrade, and impermeable material. These interpretations can also be useful to identify limitations of soils if used for septic tank absorption fields, foundations for low buildings, underground utility lines, pipelines, highways, roads, streets, and parking lots. It must be emphasized that the data and interpretation provided in the county soil surveys may not eliminate the need for sampling and testing at the site of specific engineering works that involve heavy loads or where the excavations are deeper than the depths of layers reported. However, even in these situations, the soil map is useful for planning more detailed field investigations and for suggesting the kinds of problems that may be expected. More information on the use of the soil survey data is provided in later sections dealing with specific land use types.

EFFECTS OF MINING ON SOIL FACTORS

Surface coal mining operations can have their greatest impact on the soil factors. The soils that overlay shallow coal deposits are mostly of acid sandstone and shale or of limestone and lime-bearing shale origin. Both surface and subsoil strata of the soils derived from sandstones and shales are naturally acid. The surface soil derived from the limestone and lime-bearing shales is generally slightly acid. The deep subsoil is alkaline. Slopes vary from moderately rolling to steep, and drainage varies from good to poor.

Bituminous coal deposits usually lie in horizontal planes at different depths. Each coal seam is covered with a different type of rock and soil overburden. The spoils from stripping a specific coal seam usually have similar general characteristics. There is a wide range in the acidity, stoniness, texture, and color of spoils resulting from the stripping of different coal seams. These variations can also occur in the overburden of a specific coal seam.

The soil and subsoil materials that result from surface mining operations, commonly referred to as spoils, do not resemble any type of soil that has been classified or studied by the agricultural experiment stations. The material in this cast overburden is not soil as it is known to agriculture. As previously detailed, soil in an undisturbed area consists of definite layers (horizons) of material that results from the weathering of parent materials near the surface of the earth. Each horizon has a definite structure characteristic to that horizon.

Spoil material, on the other hand, is usually composed of stones of various sizes, shale fragments, and some sand, silt, and clay particles. It has no natural soil profile or stable structure to provide normal channels for water percolation. The material is usually low in nitrogen, phosphorus, organic matter, and micro-organisms. The surface of the spoil is exposed to the elements and is subject to rapid drying. However, spoil materials have greatly increased porosity and permeability characteristics and there is usually adequate moisture beneath the surface to support plant growth in normal seasons. Sloping spoil material is usually erodible unless adequately protected by vegetative cover.

Classification

Strip mine spoils can be classified in many different ways. However, to develop reclamation plans, it is important that spoils be classified according to the factors or features that limit use, plant growth, and machinery operation. Four major factors--acidity, texture, stoniness, and slope--have been used for classifying spoil materials (Pennsylvania Research, 1971; Limstrom, 1948).

Acidity--

Acidity is a major factor because it limits plant growth and survival. Spoil material is grouped into five classes on the basis of pH range and areal extent as follows:

Class no. and description	pH value	Extent on area
1. Toxic	Less than 4.0	More than 75 percent
2. Marginal	Less than 4.0	50 to 75 percent
3. Acid	4.0 to 6.9	More than 50 percent
4. Calcareous	7.0 or more*	More than 50 percent
5. Mixed	(Too varied to be classed as any one of the above)	

*For practical purposes any soils testing 7.0 (neutral) are included in the calcareous group.

Texture--

On the basis of texture, spoils are divided into three broad groups:

Group	Description of texture
a	Chiefly sand, sandstone, or sandy shales
b	Chiefly loamy material and silty shales
c	Chiefly clay and clay shales

The acidity class and the texture groups are then combined to describe the basic soil types, such as the following examples:

Type designation	Description
4a	Calcareous sand
3b	Acid loam
1c	Toxic clay

Slope--

Slope limits land use and machinery operation. A slope of about 25 percent is maximum for hayland and pasture use and for contour operation of machinery. Spoil material is divided into two slope classes.

1. Level to steep--0 to 25 percent
2. Very steep--25 percent and over

Stoniness--

Stoniness definitely limits land use and the operation of mechanical equipment. Spoil material is grouped into two classes based on the degree of stoniness:

Nonstony--Will not interfere with seedbed preparation nor limit the use of mechanical tree planters.
Very stony--Surface or buried stones restrict seedbed preparation but will restrict tree and shrub planting by hand.

SUMMARY

A brief review of the major geomorphic factors and their influence on the suitability for various land use types has been presented. Table 15 provides a summary of the relative importance of the soil factors discussed when determining the suitability of a parcel of land for supporting various land use types. The soil factors are roughly grouped into the two categories (i.e., agricultural properties and engineering properties).

In general agricultural, recreational, forestry, and wildlife land uses are more dependent on the agricultural properties. As previously discussed, the agricultural properties of greatest concern for agricultural and related purposes include acidity or pH, texture, structure or stoniness and slope.

Residential, institutional, commercial, and industrial land uses exhibit a greater dependence on the engineering properties. The engineering properties of greatest concern for these uses include ease of excavation, flood hazard, bearing capacity, and slope.

TABLE 15. RELATIVE IMPORTANCE OF SOIL FACTORS AS DETERMINANTS OF LAND USE SUITABILITY

Land use types	Agricultural properties of soil								
	Soil profile	Texture	Structure	Organic matter	Moisture content	Permeability	pH	Depth to bedrock	Color
Forestry and wildlife	1*	2	2	1	1	2	1	2	3
Recreational	2	2	2	2	2	2	2	3	3
Agricultural	1	1	1	1	1	1	1	1	3
Residential	3	3	3	3	1	3	2	1	3
Institutional	3	3	3	3	1	3	2	1	3
Commercial	3	3	3	3	1	3	2	1	3
Industrial	3	3	3	3	1	3	2	1	3

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* 1 = Factor has high degree of influence on suitability of site for that particular land use.
2 = Factor has moderate degree of influence.
3 = Factor has low degree of influence.

(continued)

TABLE 15. (continued)

Land use types	Engineering properties of soil							
	Shrink-swell potential	Wetness	Erodibility	Flood hazard	Slope	Bearing capacity	Corrosion potential	Ease of excavation
Forestry and wildlife	3	3	2	3	3	3	3	3
Recreational	3	3	3	3	3	3	3	3
Agricultural	2	2	1	2	1	3	3	1
Residential	1	1	1	1	2	1	1	1
Institutional	1	1	3	1	1	1	1	1
Commercial	1	1	3	1	1	1	1	1
Industrial	1	1	3	1	1	1	1	1

SECTION 8

SITE CONSIDERATIONS FOR FORESTRY AND WILDLIFE

OVERVIEW

Forest covered, undeveloped rural land is the dominant land use associated with eastern coal mining districts before and after mining. Consequently this section presents an introduction and summary of the basic considerations which determine the suitability of a given site for forestry and wildlife development.

This section includes a summary discussion of the type and extent of the major American forests. Under considerations for forestry, a review of the major factors that affect the yields of forest stands is provided, an explanation of the woodland suitability groupings provided by the county soil survey report is given, and planting guidelines are briefly discussed. Under considerations for wildlife development a review of the major factors that must be considered for proper development of mine lands into lands for wildlife use is provided.

FORESTRY AS A LAND USE

The following discussion of forestry as a land use has been adapted and modified largely from the comprehensive discussion of land uses in the United States provided by Clawson et al. (1960). The reader wishing further information on forestry as both a land use and an industry is referenced to that publication.

Commercial forestry accounts for approximately 484 million acres or approximately 25 percent of the total land area in the United States (Clawson et al., 1960). Additional millions of acres have some forest cover but are used primarily for other purposes, such as recreation, grazing, wildlife, and watersheds. A great percentage of the coal deposits in the eastern and (to a lesser degree) the interior coal basins are overlain by forested land. Thus forestry, or silviculture, is both a frequent existing and postmining land use for coal mining operations.

Ideally, forestry should be considered as a land use only according to the degree to which it is a conscious growing of trees for specific purposes. The extensive forest cover encountered by the early settlers in the United States did not constitute forestry. Neither did the extensive early abuses of the forests. Intensive forestry requires conscious decisions with purposeful action about what kinds of trees to grow, what practices to use, and when to harvest them and how. In this sense, forestry in the United States is comparatively recent--hardly more than 50 years old anywhere, and widespread only for 20 years or less.

There are different degrees of forestry. Extensive forms of forestry have been followed for many decades. Forest harvest has proceeded on a commercial basis for the past century and a half, ever since colonial times. Forests will grow without care and produce some wood fiber. Moreover, fire protection will permit greater growth, and various management practices will produce even greater and better growth. Whatever grows can be harvested some day if its value warrants.

Forestry still relies primarily upon wild trees. That is, more forestry uses the trees that grow naturally on the site, either for cutting or for reproduction from their seed. If there is more than one species, harvesting practices can influence the species and even the quality of the individual trees that grow again after harvest. In some areas and for some species, artificial planting is gaining favor. Some forest tree species have been imported, and by cross-breeding, forest genetics research is developing new strains. While selection of genetically superior stock is rapidly developing, the choice is still primarily from among various strains or species of wild trees. Man's ability to develop farm crops very different from their wild ancestors--different in ways that immensely improve their usefulness when cultivated--is well documented. Nothing comparable to this can be said yet of tree development. In part, this is because the growing cycle for trees is rather long and because there has been an ample supply of wild trees to meet the increasing demands.

Even at its best, forestry is practical applied ecology; in this it resembles grazing. Man does not usually grossly alter the environment for trees as he does for farm crops (by plowing, seeding, cultivating, and annual harvesting). Instead he tries to understand and take advantage of natural processes, rather than thwart or pervert their operation. The kinds of trees, their individual size and form, their rate of growth, and many other factors of the forest can be altered, and the alteration may be in the direction of producing either less or more output. For instance, careless cutting and the indiscriminate use of fire have greatly reduced the output of many forest areas; however, careful and intensive forestry may result in much higher values than natural seeding, thinning, and decay.

Surface mining, by its very nature, must remove all the trees on the surface and the strata above the coal seam for access and exploitation. Therefore, re-establishing a suitable forest environment in mined land can be a long and difficult process, requiring detailed planning. It also requires an understanding of the basic requirements for forest and wildlife development.

MAJOR AMERICAN FOREST TYPES (Clawson et al., 1960)

The North American continent is endowed with a far greater and richer variety of forest species and types than any other part of the temperate world. In contrast to Europe, where fewer than a dozen conifers and hardwoods are the only native timber species of commercial value, the continental United States has more than a hundred.

Likewise, the original forests of the western states are entirely different from those in the East; they are larger and contain few broad-leaved trees. Except at the northern and southern edges, and very occasionally elsewhere, hardwoods are dominant everywhere in the eastern forests.

Within a forest may be found a wide variety of tree and other plant species that change with variations in soil and climatic conditions. The lower limit of tree growth in the eastern United States follows closely along the 25-in. annual precipitation line, except in river bottoms where soil moisture conditions may be exceptionally favorable. In the West, areas highly favorable for tree growth are mountainous areas that catch this amount or more of precipitation and Pacific coastal areas (such as the Douglas fir and redwood forests) where winter rainfall and summer fog are adequate to hold down transpiration rates.

The United States has been divided into six major forest regions: the northern, the central hardwood, the southern, and the tropical in the eastern United States; and the Rocky Mountain and Pacific coast in the West (Figure 27). In each of these forest regions common characteristics and tree associations are found that blend away at the edges into the adjoining forest regions. The southern region extends up along the Atlantic coast, while the northern forest runs south along the upper slopes of the Appalachian Mountains. While the combination of tree species found in each forest region is determined largely by annual precipitation, relative humidity, and temperature, the tree associations within each region, called forest types, are influenced by soil, soil moisture conditions, and slope. Pine forest types are usually found on the lighter and sandier soils; broad-leaved hardwoods on heavier soils. Other northern conifers, such as white and red spruce, balsam fir, and hemlock, prefer moist, cool locations and frequently are found only on northern slopes in the southern parts of their regions. While many species, such as oak, pine, aspen, and red maple, do very well on poor soils, tulip poplar, black walnut, basswood, and yellow birch make their best growth on rich, moist, but well-drained soils. Many species are found in swamps and bottomlands that, if well drained, grow satisfactory timber. These include black spruce, tamarack, white cedar, and black ash in the North, and bald cypress, black gum, swamp white oak, pond pine, southern white cedar, and others in the South.

While various poor-quality soils (measured on the basis of value for agriculture) do produce timber trees, they do have minimum requirements of fertility and moisture to yield satisfactory crops of wood products. Poorly drained swamps produce only stagnant tree growth of little or no value. Gravelly, droughty, south-facing slopes, such as that which occur in the Ozarks of Missouri, are such poor sites that only short-boled timber ever

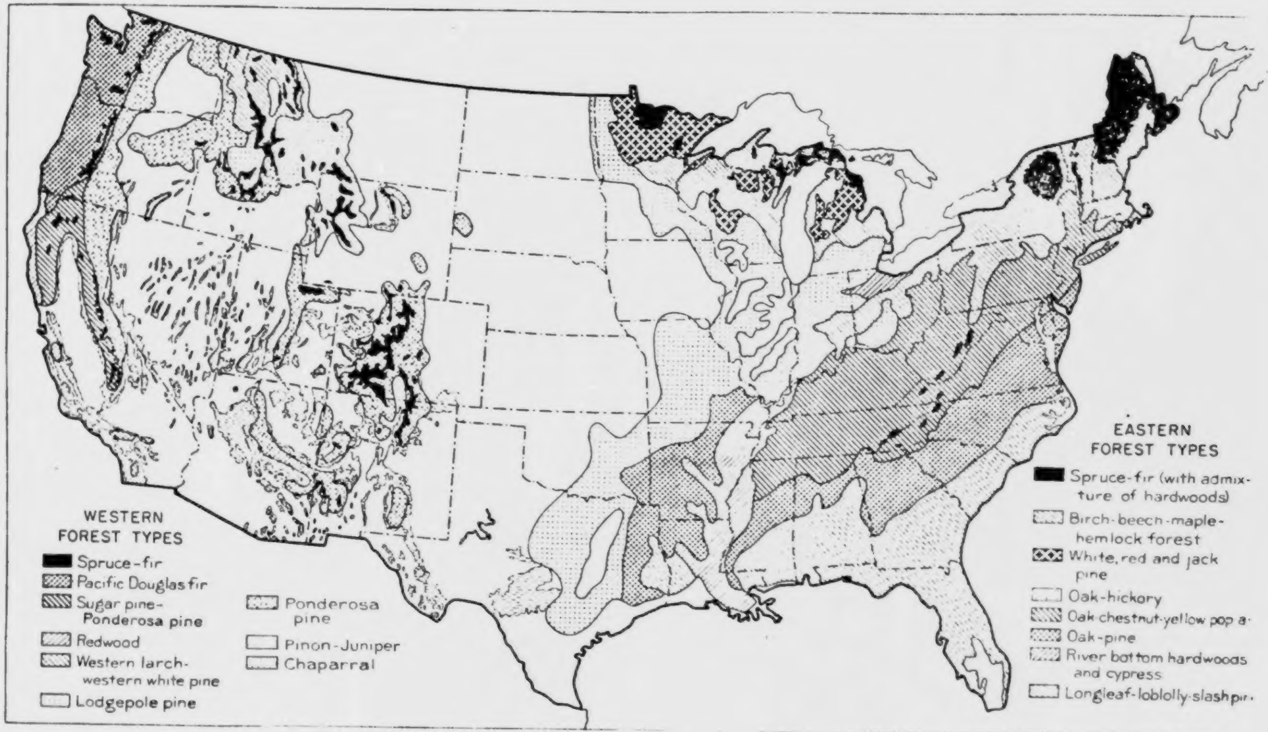
WESTERN FOREST TYPES
■ Spruce-fir
▨ Pacific Douglas fir
▨ Sugar pine-Ponderosa pine
▨ Redwood
▨ Western larch-western white pine
☐ Lodgepole pine
▨ Ponderosa pine
☐ Pinon-Juniper
☐ Chaparral
EASTERN FOREST TYPES
■ Spruce-fir (with admixture of hardwoods)
▨ Birch-beech-maple-hemlock forest
▨ White, red and jack pine
☐ Oak-hickory
▨ Oak-chestnut-yellow pop a·
▨ Oak-pine
▨ River bottom hardwoods and cypress
☐ Longleaf-loblolly-slashpi·

Figure 27. Major forest regions of the United States (Clawson, et al., 1960).

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develops. A summary of the existing terrestrial flora of the study region is provided in Volume 3 of the series, Geology of Eastern Coalfields.

CONSIDERATIONS FOR FORESTRY

Yield of Forest Stands (Toumey and Korstian, 1947)

The amount or volume of timber in a stand per unit of area at a given time is known as growing stock. Yield, on the other hand, is the volume produced by a stand of a given composition at a given age or over a definite period of time under given site conditions and treatment. The total volume of a stand at any given time is the yield of that stand for its entire period of growth to the given age, provided no part of the stand was removed earlier in thinnings. The primary purpose of studying yield in existing stands is to enable the prediction of future yields in young stands now growing and even in stands yet to be established.

Future growth in volume is predicted either by projecting the rate of growth in existing stands into the future or by accepting past growth in existing stands as an indicator of future growth on similar sites under similar conditions. The former method projects the growth in a given stand for a period of 5 to 10 years from the actual measured growth of the past 5 or 10 years. It is assumed that the growth rate of the immediate past will remain unchanged in the immediate future or, if found to have changed, that the same rate of change will continue; and this can be predicted by the projection of past growth curves into the future. The latter method makes a prediction of the probable yield from various qualities of forest land. This method assumes that the yield of stands whose past growth has been measured indicates future yield and that a relation exists between stands whose yield is known and stands whose future yield is sought.

The measurement of yield in existing stands of different qualities at some regular intervals over the life of the stands or the measurement at one time of stands of various ages (usually in 5- or 10-year age classes) and growing on different qualities of site provides the data for the construction of tables from which yield can be predicted (Table 16).

However, the predicted yield for a given stand cannot be expected to coincide exactly with that shown in the yield table, even when separate tables are available for each site class, because no two sites are exactly the same in site quality and in forest cover. Yield tables derived from periodic measurements in the same stands are considered more acceptable than similar tables derived from measurements at one time in stands of different ages. In the former tables, the past history of the stands is known and the measurements are repeated on the same sites. In the latter, the past history is unknown and the measurements are taken on different sites.

Factors Affecting Yield of Stands

The increment or total volume production on a given area is controlled by a number of factors that include: (1) species, (2) composition, (3) site

TABLE 16. GROWTH AND YIELD DATA FOR A FULLY STOCKED, UNMANAGED STAND OF SECOND-GROWTH LOBLOLLY PINE (SCS, 1967)

Site index*	Age†	Total volume per acre		Average diameter#
	Years	Cords	Board feet (Doyle)	Inches
70	20	17	---	5.4
	30	31	1,000	7.8
	40	42	3,500	9.6
	50	50	6,500	10.9
	60	55	10,000	12.1
	70	59	12,500	13.0
	80	62	15,000	13.8
80	20	22	---	6.2
	30	38	2,000	8.7
	40	51	6,000	10.7
	50	60	11,500	12.2
	60	66	16,000	13.6
	70	70	19,500	14.6
	80	73	22,000	15.5
90	20	27	---	6.9
	30	46	4,000	9.6
	40	61	10,000	11.7
	50	71	16,500	13.6
	60	78	22,000	15.0
	70	82	26,000	16.2
	80	85	29,000	17.2
100	20	32	500	7.4
	30	53	6,000	10.4
	40	71	14,500	12.8
	50	84	23,000	14.7
	60	92	29,500	16.2
	70	96	33,000	17.6
	80	100	35,500	18.6

* Height in feet of the dominant and codominant trees at age of 50 years.

† Average age of dominant and codominant trees.

Diameter of the average-sized tree at breast height.

quality, (4) form, (5) density, (6) external disturbances, and (7) silviculture treatment. A brief discussion of these factors has been excerpted and modified from a comprehensive treatment of this subject by Toumey and Korstian (1947).

Some species such as yellow poplar, aspen, and some of the pines grow much more rapidly than others such as oak, hickory, beech, and hemlock. Even on the same site quality and under similar conditions of stocking and freedom from external disturbances, a given area will yield more of one species than another.

Composition--
The composition of the stand is a factor in its yield. A pure stand on the whole has a lower increment than a mixed stand when the mixture is composed of compatible species. Thus a pure stand of Scotch pine has a lower yield than a stand composed of 90 percent pine and 10 percent beech. A pure stand of oak yields less than a stand of oak and beech. In general, the increment of a mixed stand is greater because occupation of the site is more complete. The amount of increase depends on the extent to which the species in the mixture make unlike demands on the site.

Site Quality--
Site quality refers to all the climatic, edaphic, physiographic, and biotic factors of the environment that influence growth. Because of differences in site, the yield from one site quality may be greater than from another. Both the yearly rate of growth and the total growth over a period of time depend directly or indirectly on the site factors that determine site quality.

Form--
The form of a stand refers to the age classes composing it. An even-aged stand growing on a site similar to that bearing an uneven-aged stand is essentially different in character and the yield. The maximum number of trees in the even-aged stand is in the upper crown class. In uneven-aged stands, on the other hand, each tree is in competition, not only with trees its own age but with those older and younger as well. The older age classes occupy more space than the younger and on the whole encounter less competition than the dominant individuals in an even-aged stand. Therefore, the rate of growth of a tree after it becomes dominant is more rapid. The dominant trees may, however, have experienced a period of oppression before becoming dominant, often the case in natural stands. The younger age classes occupy a relatively small percentage of the total space though the individuals constituting them far exceed in numbers those in the older age classes. The annual growth in the uneven-aged stand represents the growth of all the age classes present in the area.

Density--
In general, any degree of stocking that provides a continuous canopy gives the maximum growth. All natural stands tend to approach normal density of stocking through crown expansion. Natural spacing, however, becomes largely a matter of chance and often fails to attain full stocking. Though there is a tendency to approach normality through crown expansion, there are

places in which the canopy is incomplete and growth reduced. A greater yield from artificial stands uniformly spaced is largely dependent on the degree to which they are able to maintain a full canopy continuously during the rotation --the predetermined age at which the stands are to be cut and reproduced.

External Disturbances--

The degree to which a stand is beset by natural enemies, such as insects and fungi, influences the yield since it affects the completeness of stocking. Adverse weather conditions, climatic factors such as wind storms and ice storms, and open holes in the canopy reduce total volume production of the stand.

Silviculture Treatment--

Stands develop either under natural conditions, as in a virgin forest, or under silvicultural treatment. Since the yield of merchantable products, such as lumber and dimension materials, per unit of area and the value of these products depend more upon the species, number, size, and form of the trees brought to maturity in the stand than upon the total volume, silvicultural treatment aims to maintain the most suitable crown density throughout the life of the stand and, at the same time, to give the maximum number of trees sufficient growing space to enable them to attain their best size and form. Though it is generally recognized that a fully stocked stand is one that has an unbroken canopy (without regard to the number of trees), stands that are fully stocked when young soon become overstocked. Unless the stand exhibits great variation in dominance, overstocking dwarfs all trees and growth falls off. The natural tendency to overstock with the consequent falling off in growth, can be markedly influenced by artificial control. Silvicultural treatment stimulates growth in the crop trees by removing the others that compete with them for growing space. Initial spacing and subsequent thinnings determine the number of trees per unit of area at each period in the life of the stand. This number should be the optimum number of trees that the site will support according to their form, height, diameter growth, and quality increment. Ideal conditions for the highest yield in stands result from maintenance of normal stocking and prevention of overstocking with repeated thinnings that preserve a proper balance within the remaining stand. Since this treatment stimulates growth in the crop trees, the rotation for growing products of definite sizes can be shortened.

It is the aim of a forester to obtain just that density that will produce the highest yield and, at the same time, to grow trees of the dimensions and quality of wood that will best meet the requirements of the market.

Woodland Suitability Groups

The county soil survey report, when available, groups the soils in the county into woodland suitability groups according to their suitability for trees. Each woodland group is made up of soils that are suitable for the same kinds of trees, that require similar management, and that have the same potential productivity (Table 17).

The potential productivity of a soil for trees can be expressed as a site index. The site index for a given soil is height (in ft) that a specified

TABLE 17. SAMPLE SOIL INTERPRETATION FOR WOODLAND (Centre County, Pennsylvania, 1968)

Soils and mapping symbols		Seedling mortality	Plant competition	Equipment limitation	Hazards of		Species suitability		Site quality	
					erosion	windthrow	natural	plantation	upland oak	yellow-poplar
Albrights silt loam	59B2 59C2	Slight	Moderate	Slight	Slight	Slight	red oak yellow-poplar ash sugar maple black cherry white pine	white pine Norway spruce larch Austrian pine	Good	Good
Albrights very stony silt loam	60AB 60CD	Slight	Moderate	Moderate	Slight	Slight				
Allegheny silt loam	26B2	Slight	Severe	Slight	Slight	Slight	red oak yellow-poplar black walnut black cherry sugar maple ash white pine	white pine yellow-poplar black walnut larch Norway spruce	Very good	Very good
Amaranth silt loam	36B2	Slight	Moderate	Moderate	Slight	Slight	red oak yellow-poplar ash sugar maple black cherry white pine	white pine Norway spruce larch Austrian pine	Good	Good

(continued)

TABLE 17. (continued)

Soils and mapping symbols		Seedling mortality	Plant competition	Equipment limitation	Hazards of		Species suitability		Site quality	
					erosion	windthrow	natural	plantation	upland oak	yellow-poplar
Andover cobbly loam	48B	Severe	Severe	Severe	Slight	Moderate	red oak yellow-poplar pin oak ash white pine	white pine larch white spruce	Good	Good
	48C	Severe	Severe	Severe	Moderate	Moderate				
Andover gravelly loam	47B2	Severe	Severe	Severe	Slight	Moderate				
	47C2	Severe	Severe	Severe	Moderate	Moderate				
Andover very stony loam	49AB	Severe	Severe	Severe	Slight	Moderate				
	49CD	Severe	Severe	Severe	Moderate	Moderate				
Andover silt loam, very wet	50	Severe	Severe	Severe	Slight	Slight to moderate	pin oak red maple	white pine white spruce	pin oak only Excellent	Not adapted
Andover very stony silt loam, very wet	51									

kind of tree growing on that soil would reach in 50 years. All the soils in each woodland suitability group have approximately the same site index and are suitable for about the same kind of trees. Also about the same for each group are limitations and hazards that affect management. These hazards include seedling mortality, plant competition, equipment limitation, erosion hazard, windthrow hazard, and species suitability. The limitations and hazards are rated slight, moderate, or severe in the descriptions, similar throughout the United States, of the woodland suitability group. The range of values assigned to each of these ratings in Centre County, Pennsylvania, are reproduced for illustration (Table 17).

Seedling Mortality--

Seedling mortality refers to the loss of naturally occurring or planted tree seedlings as a result of unfavorable soil characteristics. Hazard ratings are as follows:

Slight --0 to 25 percent (expected mortality)
Moderate--25 to 50 percent
Severe --over 50 percent.

Plant Competition--

Plant competition is the rate at which brush, grass, and undesirable trees are likely to invade different kinds of soil. Hazard ratings are as follows:

Slight -- Competition will not prevent adequate natural regeneration and early growth or interfere with adequate development of planted seedlings.
Moderate--Competition will delay natural or artificial regeneration, both establishment and growth rate, but will not prevent the natural development of fully stocked normal stands.
Severe -- Competition will prevent natural or artificial regeneration without intensive site preparation and maintenance treatments such as weeding.

Equipment Limitation--

Soil characteristics and topographic features sometimes restrict or prohibit the use of equipment for harvesting trees or planting seedlings. Steepness of slope, stoniness, and wetness are the principal factors that limit the use of equipment. Hazard ratings are as follows:

Slight -- Very few limitations.
Moderate--Some problems exist, such as stones and boulders, moderately steep slopes, or wetness during some part of the year.
Severe -- Prolonged wetness of the soil or steepness and stoniness severely limit equipment. Track-type equipment is best for general use, and winches or similar special equipment may be needed.

Erosion Hazard--

The risk of erosion sometimes requires the use of practices required, in varying degrees, to reduce or control erosion in certain areas. Hazard ratings are as follows:

Slight -- Risk of erosion is low when woodcrops are harvested and few, if any, practices will be needed to control erosion.
Moderate--Erosion control measures will be needed on skid and logging roads immediately after harvesting woodcrops.
Severe -- Erosion, especially gullying, is a severe hazard where woodcrops are harvested. Harvesting and other operations should be done across the slope as much as possible. Skid trails and logging roads should be laid out on as low grades as possible, and water disposal systems should be carefully maintained during logging. Erosion control measures should be used on logging roads and skid trails immediately after logging.

Windthrow Hazard--

Windthrow hazard is an evaluation of the factors that control the development of tree roots and, consequently, the likelihood that trees will be uprooted by wind. Hazard ratings are as follows:

Slight -- Normally there are no trees blown down by the wind.
Moderate--Some trees are expected to blow down during periods of excessive soil wetness and high wind.
Severe -- Many trees are expected to blow down during periods of moderate or high winds when the soil is wet.

Species Suitability--

Certain trees are recommended because they are fast growing and have high economic value. When plans are made to develop an existing woods, it would be advisable to review the list of trees suitable for the particular soils. The landowner's objectives will determine which species to favor when plantations are to be started.

Site Quality--

Site quality indicates the ability of soils to produce timber. The ratings are based on sample plots located within the county and adjacent counties. Other soils in the county that have characteristics similar to those of the soils studied were assumed to have about the same rating. The ratings are based on the average height attained by the dominant and codominant trees at the age of 50 years. Foresters using this rating can determine the volume of timber that normal stands will produce at different ages. Site quality ratings for yellow poplar and upland oak are defined below:

1. Excellent-
   Site index - yellow poplar 95+
   - upland oak 85+

Yield - board feet per acre per year at age 50
  - yellow poplar 32,150
  - upland oak - greater than 13,750
  (Note: Published data for oak does not go beyond site index 80.)

2. Very good-
   Site index - yellow poplar 85-94
   - upland oak 75-84
   Yield - board feet per acre per year at age 50
   - yellow poplar 24,400
   - upland oak 13,750
3. Good-
   Site index - yellow poplar 75-84
   - upland oak 65-84
   Yield - board feet per acre per year at age 50
   - yellow poplar 17,620
   - upland oak 9,750
4. Fair-
   Site index - yellow poplar 65-74
   - upland oak 55-64
   Yield - board feet per acre per year at age 50
   - yellow poplar 11,400
   - upland oak 6,300
5. Poor-
   Site index - yellow poplar 55-64
   - upland oak less than 55
   Yield - board feet per acre per year at age 50
   - yellow poplar 5,600
   - upland oak 3,250 or less

The site index for other trees, such as white pine, sugar maple, ash, and larch, vary somewhat, but the better sites have the taller trees of the same species at the 50-year age and the poorer sites have smaller trees. More information on site index for other tree species can be obtained from the U.S.D.A. Soil Conservation Service and the state forestry offices.

The returns from excellent soils and good growing sites will generally justify the expenditures of money for management. However, consideration should be given to the potential yield, quality of the particular species growing on the site, and the market potential. The species and number of poor quality stems growing on such sites may prohibit the investment of money for management purposes. Also, the conversion of such areas from their present state to their potential capacity may not be economically justifiable.

Soils that are fair growing sites are the most difficult to appraise for management. A thorough appraisal of species and quality of the woodland on the site is essential. Also, the market possibility should be investigated. A proper analysis of all of these interrelated factors is essential to determine the intensity of management.

The returns from soils that are poor growing sites generally will not justify management for the production of wood products. However, woodland is usually the most practical land use for these soils. Because of unfavorable soil characteristics, these soils will generally not show a profitable return in cropland or grassland. Although returns from woodland may be slight, this land use is the most economical.

Planting Guidelines

If planting for any purpose is to be successful, attention must be given to selection of the proper species, quality of stock, planting method, season of planting, and spacing. General guidelines which have been developed for these factors are provided below (Pennsylvania Research, 1971; Pfleider, 1968).

Species--

The reclamation of mined overburden by reforestation has been practiced for approximately 40 years. The different types of material on which different species can be planted is known. A wide range of native conifers and deciduous species as well as several exotics that have become adapted to the climatic conditions are well adapted to planting and growth on these mined areas.

Because of the considerable variation in the types of spoil material and climatic conditions encountered, it is impractical to make any blanket recommendations for reforestation that can be applied throughout the surface coal mining regions. Each locality has its own individual characteristics. Certain species or mixture of species that do well in one locality in a state, or over one particular vein of coal, may not be suitable for planting in material overlying another vein in that same state. Mixtures that do well in one state may be a failure in another. Consequently the best source of information about suitable species for a given locale can be obtained from the county offices of the agricultural extension service, district foresters, and the offices of the U.S.D.A. Soil Conservation Service. Published references that provide specific recommendations for planting in the states covered by this study are available:

State	Reference(s)
Alabama	N/A
Arkansas	Limstrom (1960)
Georgia	N/A
Illinois	Boyce and Neebe (1959)
	Limstrom and Deitschman (1951)
	Grandt and Lang (1958)
Indiana	DenUyl (1955)
	Deitschman and Lane (1952)
	Striver (1949)
Iowa	Limstrom (1960)
Kansas	Limstrom (1960)
	Clark (1954)
Kentucky	Limstrom (1960)
	Boyce and Merz (1959)
Maryland	SCS (1969)
Michigan	N/A

Missouri	Limstrom (1960) Clark (1954)
Nebraska	Limstrom (1960)
North Carolina	N/A
Ohio	Finn (1958) Chapman (1944) Limstrom and Merz (1949)
Oklahoma	Limstrom (1960) Clark (1954)
Pennsylvania	Hart and Byrnes (1960) Pennsylvania Research (1971)
South Carolina	N/A
Tennessee	N/A
Virginia	Augustine et al. (1964)
West Virginia	Bondurant (1971)

Quality of Stock--

Much of the stock planted on coal mine spoils is supplied by the State Forest Tree Nurseries operated by the State Forestry Agency. Since a considerable portion of their nursery production is planted on spoils, the state nurseries grow stock especially suitable for revegetating these difficult sites. Scotch pine, however, is not raised in the state nurseries but must be obtained from private sources. A good selection of high-quality stock of other species is also available from private nurseries. A list of certified nurseries selling seedling stock is available from the county offices of the agricultural extension service, district foresters, and the offices of the U.S.D.A. Soil Convervation Service.

Cuttings of hybrid poplar are also available from state and private nurseries. The state nurseries provide two mixtures of hybrid poplars, one suitable for planting on acid spoils, one for more favorable sites. All stock, regardless of source, must meet the minimum standards of size and quality as set forth in state mining regulations.

It is extremely important to give the tree and shrub seedlings proper care from time of lifting to date of planting. Though it would be ideal to plant the trees and shrubs on the same day they are lifted, this is usually not possible. However, proper planning can keep the time between lifting and planting at a minimum. When the stock is picked up by truck at the nursery, care should be taken to protect the seedlings from drying and from exposure to the sun. Planting stock should be covered by a canvas or plastic tarpaulin or damp burlap.

Planting stock can be held in the original packages as long as five days in March or April and three days in May if placed in a cool, shaded place. If the seedlings must be held for longer periods, cold storage is desirable. Although 34°F is best for storing seedlings, any temperature above freezing and colder than air temperature is acceptable for a short time. If cold storage is not available, the trees should be heeled-in until planted (Figure 28). The first step in heeling-in is to dig a V-shaped trench deep enough to hold the roots. Trees should be removed from their bundles, the string around each bundle cut, the trees placed upright along one edge of the

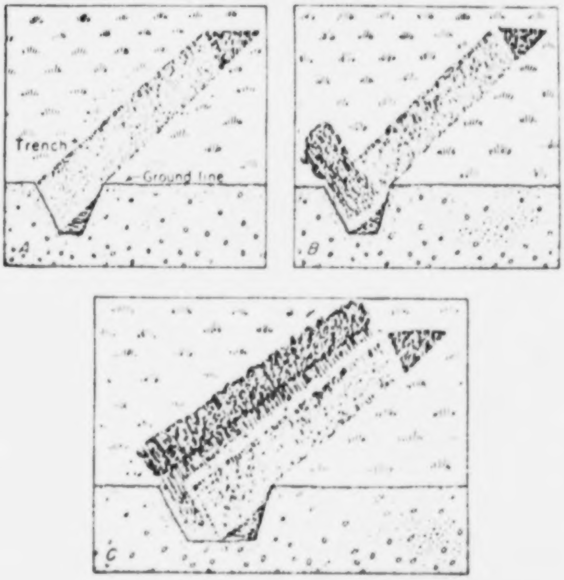

Trench
Ground line
A
B
C

Figure 28. Method of trenching and heeling-in nursery stock. A, a trench is dug deep enough to accommodate roots. B, layer of trees is laid against slanting trench wall. C, soil is piled and packed against roots, leaving trench ready for another layer of trees (Pennsylvania Research, 1971).

trench and spread out about 100 trees per ft, and the roots covered with soil. The trees should be watered immediately and kept moist, especially if the weather is hot and dry or if the trench is not shaded.

Planting Method--

Planting can be accomplished by hand (Figure 29) or machine. Use of planting machines, which is more economical than hand planting, is possible on non-stony spoil of less than 25 percent slope for most tree species. It is not practical to plant areas of less than two to three acres by machine, and planting should be done along the contour.

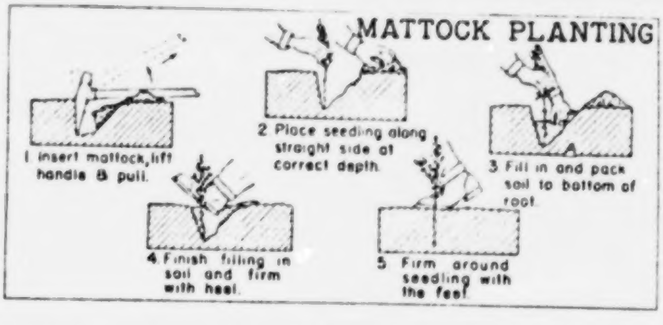

MATTOCK PLANTING
1 Insert mattock, lift handle & pull.
2 Place seedling along straight side at correct depth.
3 Fill in and pack soil to bottom of root.
4 Finish filling in soil and firm with heel.
5 Firm around seedling with the feet.

Figure 29. Correct method of planting with mattock (Pennsylvania Research, 1971).

Spacing--

The recommended spacing for planting on strip-mine spoils is 1.8m x 1.8m (6 by 6 ft.). Some Christmas tree plantings can be spaced as close as 1.5m x 1.5m (5 by 5 ft.). Hybrid poplars must be planted 2.4m x 2.4m (8 by 8 ft.) because of their rapid growth and need for growing space. If there is a good market for pulpwood nearby, it is desirable to plant alternate rows of hybrid poplars and conifers. This arrangement would provide a relatively quick pulpwood crop from the hybrid poplars and leave a permanent evergreen stand to provide a timber crop after the poplars are removed. White pine and Norway spruce are probably the best conifers to mix with hybrid poplars. When hybrid poplars are planted in alternate rows with conifers, a 2.1m x 2.1m (7- by 7-ft.) spacing should be used. If hybrid poplars are planted in alternate rows with black locust or European alders for erosion control, 2.1m x 2.1m (7- by 7-ft.) spacing can be used, but 1.8m x 1.8m (6- by 6-ft.) spacing will provide better protection to the site.

Season of Planting--

In the past, both fall and spring planting seasons were used to plant trees on strip mine spoils. However, recent studies have indicated that survival is generally better if trees are planted in the spring rather than the fall. If fall weather conditions are ideal, satisfactory survival may be realized on the better sites if planted in hardwoods, red pine, white pine, Norway spruce, or Japanese larch. However, poor results or outright failure may result if extremely acid sites below pH 4.0 are planted in the fall.

Spring planting should be done as early as possible--as soon as the frost has left the ground. Planting should be stopped during any dry spell and should terminate by May 15. If stock is kept in cold storage, planting may be extended to June 1, provided that the spoil is moist. Scotch pine is especially sensitive to dry weather and should be planted immediately after a rain or very early in the spring when the spoil is saturated. Hybrid poplars may be planted as soon as a planting bar or mattock can be used.

Direct Seeding--

For the most part, attempts to direct seed tree species on mine spoils have met with failure. Seeding of black locust has been successful in limited tests and may be attempted where spoil and site conditions are ideal. However, large-scale direct seeding of tree species is not recommended.

CONSIDERATIONS FOR WILDLIFE

Surface mined lands are well suited and useful for several types of wildlife developments. The use of reclaimed mined lands as habitat for wildlife cannot be overemphasized. The fish and wildlife services are constantly bemoaning the fact that land for wildlife is shrinking alarmingly. However, in many areas the wildlife population is growing at amazing rates on reclaimed land. Deer, small game, game birds, and wild ducks are using the reforested areas and waters, and hunters are discovering that the best hunting is frequently on an old mine site. These sites can be used for wildlife alone or integrated with other types of plantings for multiple-purpose use.

A number of factors must be considered for proper development of mine lands into wildlife uses. These factors include habitat, food availability, forage preferences, cover, and damages (Avery, 1975; Giles, 1969).

Habitat

Birds and animals frequent areas, commonly termed their habitat, that provide the kinds of food and cover that they prefer or that is necessary for their survival. Consequently, knowledge of the habitat preferences of the various species provides the basis for determining and controlling both the types and densities of species that will thrive on the reclaimed lands. The essential components of habitat include water, food, cover, and living space.

Water--

Individual species vary greatly in their water requirements. Some species, including jackrabbits, squirrels, and some grouse, may survive without a continual supply of open water by using succulent vegetation, insect food moisture, and similar sources. Other species, including the turkey and white-tailed deer, will ordinarily have a habitat requirement of open water.

The mobility and migratory habits of the animal population must be considered when developing a water supply. Non-migratory species cannot inhabit an area unless permanent water is present within reach of normal travels. In addition, the available food supply within the radius of influence of the water source must be considered because the food supply can also be a limiting factor. An animal population can be increased by increasing the number of water points and thus increasing the available food supply.

Food--

A considerable variation in food habits is found within animal species and even within individual species, depending on a number of variables that include the health and age of the animal, the season, and food availability. Many of the grasses legumes, shrubs, and trees used to stabilize and reclaim mine sites are suitable as a food supply source for wildlife uses.

An important factor in the availability of food for a particular species is the successional stage of the vegetation. Plant succession is the sequence of plant communities that replace one another in a given area. Typically, the development of the plant communities begins with pioneer stages that are replaced by a series of more mature stages until a relatively stable community is evolved. The plants of each successional stage (grass, shrub, tree) cause changes in incident sunlight, wind velocity, and temperature, as well as the structure, depth, moisture, and fertility of the soil. The changes result in the replacement of the original state by another better adapted to the modified environment. The final or mature community is called the climax.

Cover--

Different types of plant cover used for nest sites, resting, bed grounds, and other purposes will also vary with the wildlife species, its size, and mobility. It is necessary to evaluate the cover requirements for each species, since adequate cover for the cottontail will be inadequate for deer. Of equal importance to the elements of water, food, and cover is the spatial arrangement of these components. Without the proper arrangement of the essential habitat elements, there will be a poor population or none at all. Most wildlife needs all these elements within their normal daily range of movement. Moreover, if the basic elements periodically reoccur in several locales over a landscape, a highly productive population is likely to develop.

One measurable quantity that is related to the arrangement of the basic habitat elements is the amount of edge present on a given range. Edge may be defined as the total linear measure of the borderline between two distinct vegetation types (i.e., distinct to the wildlife species). Animals find these borders between classes of vegetation to be attractive because they often provide food supplies near nesting grounds, cover for travel, or provide a clear escape route near a bed ground.

Edge is a quantity that is often used to compare a productive range with a habitat of unknown ability to support wildlife. It is also a quantity subject to periodic change because of events such as forest fires and timber harvesting. A square opening of 9 hectares (22.2 acres) surrounded by forest has only about one-fourth of the edge provided by nine scattered 1 hectare (2.5 acre) openings. Edge, therefore, can be an important consideration when planning clearcut logging in conjunction with wildlife habitat requirements.

There are many techniques for measuring edge on a selected range (e.g., on type maps or aerial photographs), but the land manager must exercise keen judgment when deciding which edges will be of interest and importance to a given species of wildlife. For example, while deer might not consider a difference between two grass types significant, a grass-bush border would probably constitute an important edge.

The concept of edge is particularly important for species characterized by a limited home range and a small radius of daily mobility. It is a criterion by which management efforts on a game range can be quantified and evaluated. As a rule, the population potential of a given wildlife range is proportional to the sum of the edge in that range.

Damages and Losses from Wildlife

The destruction of forage, herbage, seeds, planted seedlings, and cultivated crops by wildlife is another factor that must be considered. Attempts to establish orchards in particular can be seriously hampered by wildlife damage unless adequate protection is provided.

PLANNING A WILDLIFE DEVELOPMENT

The basis for selecting a wildlife development plan is the evaluation of the habitat conditions existing at the site before and after the mining operations. The county soil survey report can be very useful in evaluating the habitat conditions before mining. The soil survey report, where available, provides a rating of the site for various elements of wildlife habitats and kinds of wildlife. Table 18 provides a sample evaluation.

TABLE 18. SAMPLE SOIL INTERPRETATION FOR WILDLIFE (Centre County, Pennsylvania, 1968)

Soils and map symbols	Wildlife habitat elements								Kinds of wildlife		
	Grain and seed crops	Grasses and legumes	Wild herb. upland plants	Hard-wood woody plants	Conif-erous woody plants	Wet food and cover plants	Shallow water devel.	Exca-vated ponds	Openland wildlife	Woodland wildlife	Wetland wildlife
Albrights											
silt 59B2	2*	1	1	1	3	4	4	4	1	1	4
loam 59C2	2	1	1	1	3	4	4	4	1	1	4
Albrights											
very 60AB	4	3	1	1	3	4	4	4	3	2	4
stony 60CD	4	3	1	1	3	4	4	4	3	2	4
silt loam											
Allegheny											
silt 26B2	2	1	1	1	3	4	4	4	1	1	4
loam											
Amaranth											
silt 36B2	2	2	1	1	1	4	4	4	1	1	4
loam											
Andover											
cobbly 48B	3	3	2	2	2	3	4	4	3	2	4
loam 48C	3	3	2	2	2	4	4	4	3	2	4
Andover											
gravel- 47B2	3	3	2	2	2	3	4	4	3	2	4
ly loam 47C2	3	3	2	2	2	4	4	4	3	2	4
Andover											
very 49AB	4	3	2	2	2	3	4	4	3	2	4
stony 49CD	4	3	2	2	2	4	4	4	3	2	4
loam											

* 1 = Well suited
2 = Suited
3 = Poorly suited
4 = Unsuited

Ratings of Habitat Elements

Ratings used for the various habitat elements and major groups of wildlife are defined as follows:

1. Well suited--Can be easily created, improved, or maintained. Few limitations in management and satisfactory results are easily obtained.
2. Suited--Can be created, improved, or maintained. Moderate limitations affect management. Moderate intensity of management and frequent changes may be required for satisfactory results.
3. Poorly suited--Can be created, improved, or maintained. Severe limitations affect management and may make it difficult or expensive to maintain.
4. Unsuited--Impractical to create, improve, or maintain. Satisfactory results are improbable.

These ratings indicate only potential suitability. Changes in land use may completely alter site conditions and thus alter the species of wildlife that inhabit the area. Also, the ability of wildlife to move from place to place is not considered in making these ratings.

Habitats Essential for Major Groups of Wildlife--

The county soil survey classifies wildlife into three major groupings. These three major groups of wildlife and the various habitat elements essential for them are defined in the following paragraphs:

Openland wildlife--This group includes birds and mammals commonly found in open situations such as crop fields, meadows, pastures, and nonforested overgrown lands. Common examples of openland wildlife are quail, pheasants, doves, woodcock, cottontail rabbits, meadowlarks, killdeer, and field sparrows.

Habitat elements essential for openland wildlife include various combinations of the following types of vegetation, depending upon the individual species:

1. Grain and seed crops--Domestic grain and seed producing annual plants such as corn, wheat, millet, sorghum, soybeans, buckwheat, rowpeas, oats, rye, and barley.
2. Grasses and legumes--Domestic perennial grasses and herbaceous legumes such as timothy, alfalfa, reed, canary grass, lespedeza, alsike clover, ladino clover, red clover, tall fescue, bromegrass, and bluegrass.
3. Wild herbaceous upland plants--Wild perennial grasses and weeds such as goldenrod, ragweed, pokeweed, panicgrass, partridgepeas, beggarticks, various native lespedezas, and other nature herbs.
4. Hardwood woody plants--Deciduous trees as well as shrubs or vines such as oaks, dogwoods, grapes and briars. These are required to a lesser degree than the preceeding three types of vegetation.

Some hardwood trees and shrubs are valuable for wildlife because they grow vigorously and produce a good crop when they are planted or when they seed naturally. Among these are sumac, dogwood, persimmon, sassafras, hazelnut, shrub lespedeza, multiflora rose, autumn-olive, wild cherry, various oaks and hickories, bayberry, blueberry, huckleberry, high-bush cranberry, blackhaw, sweetgum, and various hollies.

Woodland wildlife--This group includes birds and mammals, such as grouse, turkeys, deer, squirrels, wood thrushes, warblers, and vireos, commonly found in wooded areas.

Habitat elements essential for woodland wildlife include various combinations of the grasses and legumes, wild herbaceous upland plants, and hardwood woody plants--as listed under openland wildlife--plus the following type of vegetation:

> Coniferous Woody Plants - Cone-bearing trees and shrubs such as pines, cedars, and yews. Pine species include Virginia pine, loblolly pine, shortleaf pine, red pine, Scotch pine, and pond pine. Cedar species include red cedar and Atlantic white cedar.

Wetland wildlife--This group includes birds and mammals such as ducks, geese, rails, snipe, muskrat, mink, and beaver, commonly found in marshes and swamps.

Habitat elements essential for wetland wildlife include various combinations of the following:

1. Wetland Food Plants - Wild herbaceous plants of moist to wet sites exclusive of submerged and floating aquatic plants. Examples of plants that provide food and cover for waterfowl and fur-bearing animals are smart weed, wildrice, barnyard grass, bulrush, pondweed, duckweed, arrow-arum, pickerelweed, waterwillow, cattail, and various sedges.
2. Shallow Water Development - The suitability of a soil for shallow water impoundments depends on the ease or difficulty in controlling the water. Impoundments for the control of water where the depth generally does not exceed five feet such as low dikes, shallow dugout areas, level ditches and water control devices on marshy streams are considered suitable for shallow water developments. In or on soils suitable for these impoundments, the water table can be controlled at a level ranging from the natural water table to within two feet of it.
3. Excavated Ponds - The suitability of a soil for constructing excavated ponds depends on how well the pond is supplied by the groundwater. These ponds must not depend upon runoff from surrounding areas, though that water may help to keep the pond at the desired level. Impounded areas with ample supplies of water of suitable quality and depth for fish and wildlife, such as a one-quarter-acre pond with an average depth of six feet, would be considered suitable.

SECTION 9

SITE CONSIDERATIONS FOR AGRICULTURAL USES

OVERVIEW

Agriculture is the second most common land use associated with the eastern coal districts, before and after mining. In a number of cases, particularly in Appalachia, the clearing, grubbing and leveling of the land surface creates an opportunity to convert the mine site from a forestry land use prior to mining to an agricultural or grazing land use as part of the reclamation process. However, in other areas, particularly those designated as prime agricultural lands, surface mining operations may be restricted or prohibited due to the concern that the mining process may substantially reduce the productivity of the soils.

This section introduces and summarizes a number of the basic considerations pertinent to the development of land for agricultural use. It includes a review of recent developments and trends in agriculture and a brief description of the major types of farming operations and regions in the United States. The influence of cultural and natural factors on agricultural land use are discussed. Important concepts and tools including the land capability classification of soils developed by the U. S. Department of Agriculture, and crop yield estimates and their relationship to soil productivity and levels of management are presented.

RECENT TRENDS IN AGRICULTURE

American agricultural patterns over the last few decades have been experiencing a revolutionary transitional period characterized in general by a shift towards a business and managerial type of operation with increasingly heavy emphasis on relatively large-scale programs and large blocks of capital investment. Concurrent with growing demands for agricultural products, the number of farms declined from approximately 7 million in the mid-1930's to nearly half that number in the mid-1960's. At the same time the average size of farms has increased. Farms of 1,000 acres or more (less than 4 percent of the total) account for approximately half of all farmland, but the average farm size is approximately 300 acres. The top 3 percent of the farms account for more farm production than the bottom 78 percent (Weimer and Hoyt, 1966).

The driving forces behind these changes have been the remarkable scientific and technological advances, including improved feeds and fertilizers, more effective plant and animal breeding, better agricultural implements and power, as well as improved roads and trucks and related changes. There have been marketing changes as well; contract farming has increased in importance as have the efforts of various farm cooperatives. Throughout these many changes, government programs--including various controls and supports--have played an important role.

MAJOR TYPES OF FARMING

Farming operations in the United States have been classified into eighteen major groupings. These major groupings displayed in Figure 30, include:

1. Dairy,
2. Wheat and small grains,
3. Range livestock,
4. Cotton,
5. Subtropical crops,
6. Tobacco,
7. Self sufficing,
8. Corn,
9. General farming,
10. Fruit and general farming,
11. Potatoes,
12. Sugar beets,
13. Truck farming,
14. Rice,
15. Field beans,
16. Sugar cane,
17. Peanuts,
18. Non-agricultural.

These major types of farming operations tend to concentrate within the regions of the United States that are most suitable for each type of operation (Figure 30). Thus major agricultural regions in the United States delineate some of the broad groupings of types of farming that characterize particular parts of the country. These regions are only oversimplified and partial images of complex farming situations. Wide variations in types of farming occur in each region.

The major agricultural regions include the northern dairy regions, the corn belt, the cotton belt, the wheat regions, the western grazing region, and the general farming region. This report deals with the eastern and interior coal regions, which encompass the northern dairy region, the corn belt, the cotton belt, and the general farming region. A discussion of farming practices in these regions can be obtained by referring to Hopkins and Murray, 1953 and USDA, 1958.

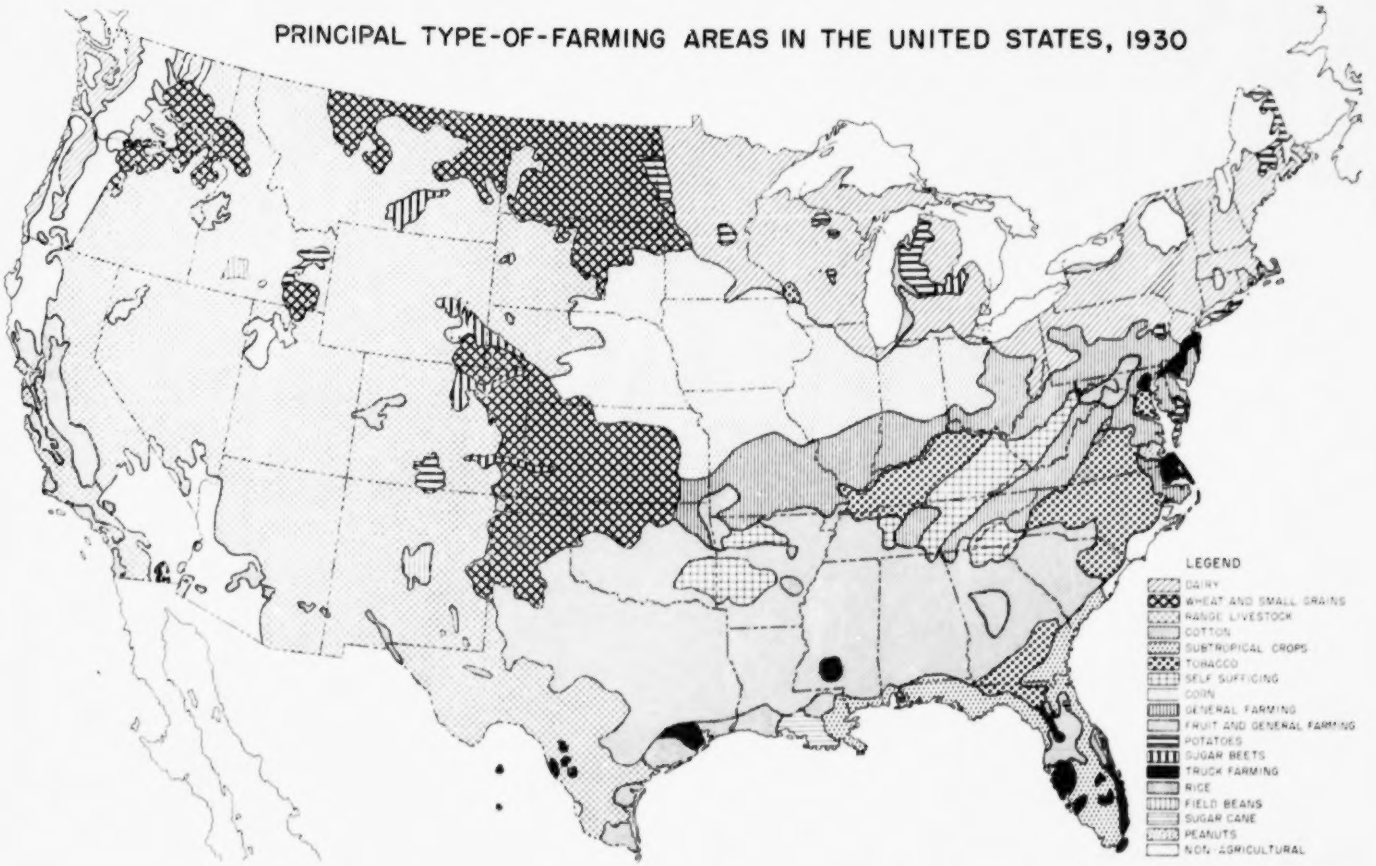

PRINCIPAL TYPE-OF-FARMING AREAS IN THE UNITED STATES, 1930
LEGEND
DAIRY
WHEAT AND SMALL GRAINS
RANGE LIVESTOCK
COTTON
SUBTROPICAL CROPS
TOBACCO
SELF SUFFICING
CORN
GENERAL FARMING
FRUIT AND GENERAL FARMING
POTATOES
SUGAR BEETS
TRUCK FARMING
RICE
FIELD BEANS
SUGAR CANE
PEANUTS
NON-AGRICULTURAL

Figure 30. Principal type of farming areas in the United States (NRPB, 1943).

INFLUENCE OF CULTURAL FACTORS ON AGRICULTURAL LAND USE

The cultural factors previously discussed in Section 4, location, accessibility, size and shape, surrounding land uses, and intensity of use (zoning) are not as critical in determining the suitability of land for agriculture as they are for the more intensive uses. However, they are still of considerable importance, particularly from an economic standpoint. These factors have to do with man and his relation to the land--proximity to markets, communication facilities, public and private investment, patterns of ownership and management, and other institutional arrangements.

Comparative Advantage

The following discussion on the principle of comparative advantage, an important concept in geographic economy, has been condensed from a more comprehensive discussion by Mighell (1958). Economists have attempted to explain the different uses of land in terms of the principle of comparative advantage. Land used according to its comparative advantage is used to produce the commodity or combination of commodities that pays better than any other commodity or combination of commodities under the given circumstances. Though simple in concept, the actual determination of what pays best is often a complicated task since changing technology and changing conditions of demand and supply mean that comparative advantage is forever shifting.

Some areas possess what is termed an absolute advantage in production of certain commodities. Winter vegetables grow only in frost-free areas. Bananas grow only in certain tropical situations. Cotton grows only within a given temperature range. Tobacco grows only on certain soil types.

An absolute advantage is only an extreme form of comparative advantage, however. The usual situations are those in which any of a large number of products can be grown but in which a few have relatively greater advantage. Frequently this is because the yields of the commodities grown are higher than yields in competing areas, but this may not be true; it may be only that the commodities are a better value than competing products in the same area.

The role of demand in this process should be emphasized. An area may be capable of growing a fine crop of potatoes, for example, and yet in actual practice it will be used to grow only a fair crop of soybeans. Land capable of growing high yields of potatoes is relatively abundant in the United States but land capable of growing soybeans is not (relative to the country's need for each crop).

Specialization and Diversification

Farming in the United States is more specialized than farming in most countries, but this specialization does not usually express itself in single product farming. A combination of two or three products usually has a greater advantage in the use of land and other resources than any single product has. The seasonal nature of crop production and the uneven distribution of labor and machinery inputs open the way for special savings when nonconflicting enterprises are dovetailed. Similar circumstances arise in livestock production. The interrelationships between feed crops and livestock often form the basis for profitable combinations in an operating farm unit.

Unique circumstances result in single-product specialization in a few highly specialized types of production. These specialized products include cranberries, citrus, and many other fruits and nuts. Among livestock production, chickens are another example of a specialized product.

Regional Competition--

The following brief discussion of regional competition and the subsequent discussion of transportation costs have been condensed from a more comprehensive treatment of these topics by Hopkins and Murray (1953). If two crops can be grown equally well in the same area, determination of which crop to grow is based on a combination of crop value and climate conditions. If the value of one of these crops gives it an advantage over the other, it will tend to crowd out the less profitable one.

Suppose, however, that one of the crops is cotton, which can be grown only in a limited area (the southern states in this country), and that the other is corn, which can be grown in the cotton belt and in other areas as well. In such a case, the crop that is adapted to the more limited conditions will probably have its choice of area while the other crop will probably be produced elsewhere. The production of cotton is more limited than the production of corn by climate and other conditions. Therefore, in regions where cotton grows well, farmers make more money by raising cotton than they do by producing corn.

Which crop is more profitable depends partly on the price received and partly on the cost of production. A satisfactory mechanical cotton picker would lower the cost of producing cotton and would, therefore, encourage increased production. But an increase in cotton production would tend to lower its price. In the long run, expansion would be limited by this decline in price.

Transportation Costs--

Transportation costs are important in determining whether a crop product is to be marketed as such or converted into a more concentrated livestock product. A farmer living in the eastern part of the dairy belt might find it profitable to sell baled hay, but if he lives in a western state, he would probably get more for the hay if he first fed it to cattle or sheep.

Eastward--toward the consuming centers--the advantages of crop products used as feed decrease. Eventually a point is reached where it pays to market the grain itself rather than the concentrated livestock product. In eastern markets the prices of such commodities as wheat, corn, hogs and beef cattle, which are shipped there, tend to equal the prices in western markets plus freight and handling charges. In choosing his principal enterprise, the farmer should study prices and transportation costs carefully in order to determine the advantages of his particular locality. He should also consider the possiblity of converting his crops into more concentrated products that may be marketed more economically.

Another consideration in any study of transportation costs is the relative perishability of the product. Transportation costs, as well as losses from spoilage, are greater, of course, for products that deteriorate rapidly. Therefore, fluid milk and green vegetables are usually produced in areas near large cities. Every improvement in transportation methods, such as refrigeration, tends to increase the number of areas where the products may be grown profitably. Fruits, vegetables, and milk are now shipped long distances to market, but this is even more true of the less perishable fruits and out-of-season products.

INFLUENCE OF NATURAL FACTORS ON AGRICULTURAL LAND USE

The natural factors arranged and discussed under the three major groupings of climate, geomorphology, and soils (Sections 4, 5 and 6 of this report) are generally the dominant factors in determining the suitability of agricultural land uses. A brief discussion of the influence that these factors exert on selecting suitable crops and farming systems is provided.

Climate

The climatic factors, including precipitation, temperature, humidity, solar radiation, and wind, are important considerations and often represent the controlling factors in determining the suitability of a crop for a given area. In fact, knowledge of the crops and crop varieties grown in a given region can often provide a better measure of climate, as applied to crop production, than complete climatic records (Martin, et al., 1976).

The climate of an area or region sets the limits on three important parameters associated with plant growth. These include (a) length of growing season, (b) temperature, and (c) amount of sunshine and rainfall.

Various crops exhibit preferences for different climatic conditions. For example, oats and potatoes are crops that grow well in a relatively cool climate with a short growing season. Corn requires a warmer growing season than oats and grows best in rather moist air with the temperature between 80°F and 90°F. Cotton also needs a moist, warm climate but requires a longer growing season, usually 200 days or more.

Among the forage crops, alfalfa does well in a relatively dry climate, but most of the grasses grow better if they have more moisture. For all these crops, clear sunny days are needed for harvest. Cloudy, rainy days during harvest increase the cost of harvesting and result in a poorer quality of hay. Each crop does better under a certain combination of climatic conditions than under a continuation of the same conditions for the entire season.

A brief review of the influence of the climatic factors on crop selection follows. This material has been summarized from a discussion of these factors by Martin, et al. (1976). Additional information on this topic is available from the U. S. Department of Agriculture (USDA, 1941).

Precipitation--

The following four distinct crop regions in the United States have been classified on the basis of average annual rainfall (Martin, et al., 1976):

1. The arid region is characterized by an average annual rainfall of 25 cm (10 in.) or less. Irrigation is necessary for successful crop production in most arid areas.
2. The semiarid region is defined by an average annual rainfall ranging from 25 to 51 cm (10 to 20 in.). Tillage methods that conserve moisture, crop varieties adapted to dry farming regions, or irrigation are necessary for successful crop production.
3. The sub-humid region averages annual rainfall that varies from 51 to 76 cm (20 to 30 in.). Amount of rainfall often is inadequate for satisfactory crop yields unless methods utilizing the rainfall to best advantage are followed in regions such as the southern Great Plains, where seasonal evaporation is high.
4. The humid region is defined by an average annual rainfall of more than 76 cm (30 in.). Conservation of moisture is not the dominant factor in crop production. This region encompasses all of the twenty eastern states covered by this report.

The total annual precipitation and, in particular, the seasonal characteristics of that precipitation are closely related to the type of crop that can be grown economically. In semiarid regions, such as the Great Plains and Great Basin, conservation and utilization of the scanty rainfall is so important that it relegates all other factors, including soil fertility, to minor positions (Martin, et al., 1976).

Seasonal distribution of rainfall as well as the characteristics of individual storms (storm duration and intensity) determine the effectiveness of rainfall for crop production. Rainfall has its greatest value when it falls during the growing season--ordinarily between April 1 and September 30 for summer crops. The critical period for moisture for most crops occurs just before or after flowering. In regions of winter rainfall, a greater portion of the water can be conserved by fallowing than in regions of summer rain because it falls during a period of low evaporation. Winter rainfall regions are especially suited to the growing of winter grain, though these crops thrive in summer rainfall regions also. Corn and sorghum are poorly adapted to winter rainfall regions because their greatest demands for moisture occur during the dry hot season. Seasonal and annual precipitation data for the study region is provided in Volume 3.

Ordinarily, summer showers of less than 1/2 in. are of very little value in storing soil moisture for the use of crops unless they immediately precede or follow other rains. Light showers are largely lost by evaporation from plant foliage and soil surface. However, such showers may benefit crops by reducing evaporation and cooling the atmosphere. Frequently, rain comes in torrential showers in the Great Plains and states to the east, with the result that much of it is lost through runoff, especially on steep lands with heavy soils.

Temperature--

Temperature is an important factor in limiting the growing of certain crops. The 10°C (50°F) isotherm of monthly mean temperature during each summer month marks the growth limits for most plants. The great crop areas have 4 to 12 months in which the mean monthly temperature is between 10°C and 20°C (50°F and 68°F). This is in the temperate belt.

Each crop plant has its own temperature range--i.e., its minimum, optimum, and maximum for growth. Though they are subjected to a rather wide range of temperature, most crop plants make their best development between 15°C and 33°C (60°F and 90°F). They either cease growing or die when the temperature becomes too low or too high.

Crop areas have more or less definite boundaries that extend in an east-west direction in conformity with the isothermal trend. The time to plant crops is defined by the temperature conditions of the locality, but the planting time is generally later as one proceeds northward. According to the Hopkins bioclimatic law, such events as seeding time vary 4 days for 1 degree of latitude, 5 degrees of longitude, and 122 meters (400 ft.) of altitude, being later northward, eastward, and upward in the United States. The normal daily temperature for spring planting of a given crop is rather uniform throughout the country. Temperature data for the study region is provided in Volume 3.

Humidity--

Evaporation and transpiration increase with increases in temperature and decreases in relative humidity. A high seasonal evaporation from a freewater surface is generally reflected in a high water requirement of crops. Evaporation determines the efficiency of rainfall, particularly under a rainfall of less than 76 cm (30 in.) per year. Each additional inch (2.54 cm) in seasonal evaporation increases the water requirement to produce a short ton of dry matter (907 Kg) by about 14-18 tons (12.7-16.3 metric tons).

The rainfall-evaporation ratio is sometimes used as an index of the external moisture relations of plants, a ratio of 100 percent meaning that rainfall and evaporation are equal. This ratio ranges from 110 to 130 percent along the Atlantic coast, but westward it drops gradually to 20 percent at the base of the Rocky Mountains. Only xerophytic shrubs and grasses can thrive where rainfall is so far below evaporation.

Light--

Light is necessary for the formation of chlorophyll in green plants and for photosynthesis, the process of manufacturing food essential to plant growth. Plant growth may increase with greater light intensities of up to 19,375 luxes, or meter candles, (1,800 foot candles) or more, an intensity of about one-fourth to one-half of normal summer sunshine. Maximum solar radiation may exceed 107,640 luxes (10,000 foot candles). The hours of sunlight each day vary from a nearly uniform 12-hour day at the equator to continuous light or darkness throughout the 24 hours for a part of the year at the poles. The day length is approximately 12 hours everywhere at the time of the vernal and the autumnal equinoxes.

The life processes of many plants are influenced by the relative lengths of day and night. This phenomenon, called photoperiodism, led to the distinction between long-day and short-day plants. Long-day plants require a relatively long day for the formation of inflorescences, but they increase in vegetative growth when the days are short. Among the long-day plants are red clover and the small grains (except rice) that ordinarily flower in the long days of early summer. Long days hasten flowering and maturity of these crops but reduce vegetative growth. Short-day plants are stimulated to vegetative growth, with delayed flowering and maturity, when the days are long, and produce flowers and fruits when the days are relatively short. Corn, sorghum, rice, millet, and soybeans are short-day plants. In one experiment, Biloxi soybean plants grew 9 in. tall and flowered in 23 days under a 10 1/2-hour photoperiod but were 30 in. tall and flowered in 60 days under a 14 1/2-hour photoperiod. The length of the night (dark period)--rather than the length of the day--is the critical determinant, though light is essential also for the complete photoperiodic reaction.

Wind--

Wind may cause mechanical lacerations and bruises to the tissues of crop plants. High winds may bruise and tear the leaves or, as often happens with small grains grown on fertile soils, the plants may be blown over or lodged. The rate of transpiration or water loss from plants increases in proportion to the square root of the wind velocity. In high winds crop plants may be cut off by moving sand particles, completely uprooted, or buried under soil drifts.

Soil Factors

Though less important than climate, soil factors play a major role in determining which crops are grown. Despite popular belief, soil structure and chemical reaction have only a minor effect in determining the variety of a particular crop that is grown. Surveys of crop varieties show that their distribution is determined largely by climatic and soil-moisture factors.

The U. S. Department of Agriculture has developed a land-capability classification of soils that is a grouping of soils to show, in a general way, suitability for most kinds of farming. It is a practical classification based on limitations of the soils, the risk of damage when they are used, and the way they respond to treatment. Soils are classified according to degree and kind of permanent limitation but without consideration of possible but unlikely major reclamation properties. Knuti, et al. (1970) summarizes the major physical features of land and soil classifications:

Physical Features of Land and Soil (Knuti, et al., 1970)

Surface Soil Texture

Coarse
Medium
Fine

Subsoil Texture

Coarse
Medium
Fine

Depth of Surface Soil and Subsoil

Deep
Moderately deep
Shallow
Very shallow

Topsoil Color

Light
Medium
Dark

Soil Structure

Platy
Prismatic
Columnar
Blocky
Granular
Single-grain
Massive

Stoniness

Free
Slight
Moderate
Excessive

Ease of Cultivation

Not difficult
Difficult
Very difficult

Subsoil Permeability

Very slow
Slow
Moderate
Rapid

Surface Drainage

Poor
Fair
Good
Excessive

Internal Drainage

Excessive
Good
Fair
Poor

Percent of Slope

Nearly level
Gently sloping
Moderately sloping
Strongly sloping
Very steep

Erosion

None to slight
Moderate
Severe
Very severe

Erosion Hazard When Under Cultivation

None to slight
Moderate
Severe

Factors Used in Selecting Land Classes

Texture
Permeability
Depth
Slope
Erosion
Drainage

The soils capability system groups all soils at three levels--the capability class, subclass, and unit. These groups are discussed below.

Soil Capability Classes--

Soil conservation specialists have set up a system of land classification, divided into eight use or capability classes, designated by Roman numerals I through VIII. Higher numerals indicate progressively greater limitations and narrower choices for practical use. Classes I to IV are suitable for cultivation, classes V to VIII for permanent vegetation. Figure 31 graphically illustrates the intensity with which each land-capability class can be safely used (Buckman and Brady, 1972). A good description of the various classes is provided below (Buckman and Brady, 1972).

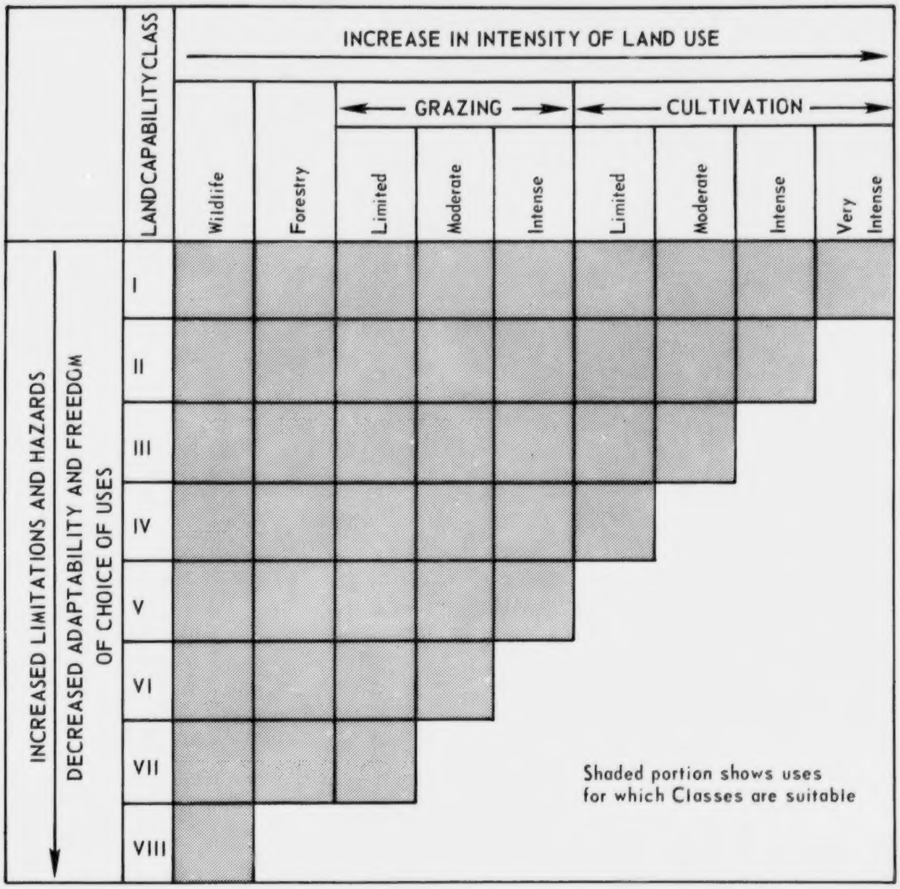

INCREASE IN INTENSITY OF LAND USE
LAND CAPABILITY CLASS
GRAZING
CULTIVATION
Wildlife
Forestry
Limited
Moderate
Intense
Limited
Moderate
Intense
Very Intense
INCREASED LIMITATIONS AND HAZARDS
DECREASED ADAPTABILITY AND FREEDOM OF CHOICE OF USES
I
II
III
IV
V
VI
VII
VIII
Shaded portion shows uses for which Classes are suitable

Figure 31. Land capability classes and limitations (Buckman and Brady, 1972).

Class I--Soils found in this land class have few limitations that restrict their use. They can be cropped intensively or used for pasture, range, woodlands, or even for wildlife preserves. The soils are deep and well drained, and the land is nearly level. They are either naturally fertile or have characteristics that encourage good response of crops to application of fertilizer.

The water-holding capacity of soils in class I is high. In arid and semi-arid areas, soils having all the other favorable characteristics mentioned above may be in class I if they are irrigated by a permanent irrigation system.

The soils in class I need only ordinary crop-management practices to maintain their productivity. These practices include the use of fertilizer and lime and the return of manure and crop residues, including green manures. Crop rotations are also followed.

Class II--Soils in this class have some limitations that reduce the choice of plants or require moderate conservation practices. These soils may be used for the same crops as class I. However, they are capable of sustaining less intensive cropping systems or--with the same cropping systems--they require some conservation practices.

The use of soils in class II may be limited by one or more factors, such as (1) gentle slopes, (2) moderate erosion hazards, (3) inadequate soil depth, (4) less than ideal soil structure and workability, (5) slight to moderate alkali or saline conditions, and (6) somewhat restricted drainage.

The management practices that may be required for soils in class II include terracing, strip cropping, contour tillage, rotations involving grasses and legumes, and grassed waterways. In addition, those practices that are used on class I land are also generally required for soils in class II.

Class III--Soils in class III have severe limitations that reduce the choice of plants or require special conservation practices or both. The same crops can be grown on class III land as on classes I and II. The amount of clean, cultivated land is restricted, however, as is the choice of the particular crop to be used. Crops that provide soil cover such as grasses and legumes, must be more prominent in the rotations used.

Limitations in the use of soils in class III result from factors such as (1) moderately steep slopes, (2) high erosion hazards, (3) very slow water permeability, (4) shallow depth and restricted root zone, (5) low water-holding capacity, (6) low fertility, (7) moderate alkali or saline conditions, and (8) unstable soil structure.

Soils in class III often require special conservation practices. Those mentioned for class II land must be employed, frequently in combination with restrictions in kinds of crops. Tile or other drainage systems may also be needed.

Class IV--Soils in this class can be used for cultivation but with very severe limitations on the choice of crops. Also, very careful management may be required. The alternative uses of these soils are more than for class III. Close-growing crops must be used extensively, and row crops cannot be grown safely in most cases. The choice of crops may be limited by excess moisture as well as by erosion hazards.

The most limiting factors on these soils may be one or more of the following: (1) steep slopes, (2) severe erosion susceptibility, (3) severe past erosion, (4) shallow soils, (5) low water-holding capacity, (6) poor drainage, and (7) severe alkali or saline conditions. Soil conservation practices must be applied more frequently than on soils in class III. Also, they are usually combined with severe limitations in choice of crop.

Class V--Soils in class V to VIII are generally not suited to cultivation. Those in class V are limited in their safe use by factors other than erosion hazards. Examples of such limitations follow: (1) subject to frequent stream overflow, (2) growing season too short for crop plants, (3) stony or rocky soils, and (4) ponded areas where drainage is not feasible. Often pastures can be improved on this class of land.

Class VI--Soils in this class have severe limitations that restrict their use largely to pasture or range, woodland, or wildlife. The limitations are the same as those for class IV land but more severe.

Class VII--Soils in class VII have very severe limitations that restrict their use to grazing, woodland, or wildlife. The physical limitations are the same as class VI land except they are so severe that pasture improvement is impractical.

Class VIII--In this land class are soils that should not be used for any kind of commercial plant production. Though their use is restricted, these soils can be used for aesthetic purposes as well as for recreation, wildlife, and water supply. Examples of kinds of soils or land forms included in class VIII are sandy beaches, river wash, and rock outcrop.

Capability Subclasses--

In each of the land capability classes are subclasses that have the same kind of dominant limitation for agriculture. These subclasses are designated by adding a small letter--e, w, s, or c--to the class numeral (for example, IIe). The letter e shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; w shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); s indicates that the soil is limited, mainly because it is shallow, droughty, or stony; and c is used in some parts of the United States to designate that the chief limitation is climate that is too cold or droughty.

Note: Subclass designations are not used for every soil classification. For example, in class I there are no subclasses because the soils of this class have few limitations. Class V can contain, at the most, only subclasses w, s, and c because the soils in it are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife, or recreation.

Capability Units--

These units are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus the capability unit is a convenient grouping for making many statements about the management of soils. The major management practices in use can be summarized as follows:

Recommended Conservation and Management Practices

(Knuti, et al., 1970)

Vegetative

1. Use one- or two-year crop rotation.
2. Use three- or four-year crop rotation.
3. Use five-year or longer crop rotation.
4. Put into permanent pasture.
5. Put into permanent woodland.
6. Do not burn crop residue.
7. Use strip cropping.
8. Use crop residue management.
9. Establish recommended grasses and/or legumes.
10. Protect from burning.
11. Control grazing.
12. Control noxious plants.
13. Control brush or trees.
14. Use only for wildlife or recreation area.
15. Establish grass waterways.
16. Use green manure.
17. Use summer fallow.

Mechanical

1. Terrace and farm on the contour.
2. Use contour strip cropping.
3. Maintain terraces.
4. Construct diversion terraces.
5. Install a drainage system.
6. Level the land.
7. Clear rocks, brush, and/or trees.
8. Irrigate.
9. Control gullies.
10. Maintain trash cover.

Fertilizer and soil amendments

Lime
Gypsum
Sulfur
Manure
Nitrogen
Phosphorus
Potash
Complete fertilizer
Minor elements

Capability units are generally designated by adding an Arabic numeral to the subclass symbol--for example, IIe-4, or IIIe-6. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation, the small letter indicates the subclass, or kind of limitation, and the Arabic numeral specifically identifies the capability unit within each subclass.

The county soil survey report usually provides a rating of each soil listed in the survey for its cropland suitability. Table 19 is an example of the type of rating provided. These ratings do not apply to suitability for specialty crops, permanent pasture, wildlife, or woodland. This information is useful in determining the conservation practices needed to overcome the limitations. Productivity potential ratings for two commonly grown crops are shown in the last two columns. These ratings are based upon crop yield estimates contained in the U.S.D.A. Soil Conservation Technical Guide on file in the county office.

Local soil conservation service personnel can provide on-the-farm technical assistance in planning, applying, and maintaining conservation farm systems of management. Additional information on crop yields and costs and returns for a wide variety of crops on various soils can also be obtained from the local office.

Geomorphology

The geomorphic factors that include topography, elevation, slope, exposure, and drainage discussed in Section 5 play an important role in determining the suitability of a site for agricultural use, mainly through their influence upon the directly operating climatic and soil factors. The local or micro-climate, in contrast to general climate, is largely determined by geomorphic factors. Geomorphology within a given climatic province, through its effect on local climate and soil, causes a variety of plant communities to develop, each of which has a more or less distinct physiognomy. The intimate relation that exists between the geomorphology of a region and the grouping of its flora is primarily due to effect of geomorphology upon the water content and composition of the soil.

Many of the geomorphic factors, notably slope and drainage, are included in the land capability classification of soils.

CROP YIELD ESTIMATES

Estimates of the average crop yields that may be expected from the soil types and phases shown on the soil map are an essential part of soil survey reports. This discussion on crop yield estimates is abstracted from the U.S.D.A. Soil Survey Manual (USDA, 1951). These predicted crop yields and the definitions of management that may be expected to produce them are essential for the interpretative groupings of soils according to soil-use capability, crop adaptibility, management requirements, etc. These estimates are basic inputs for agricultural and economic interpretations.

A productivity table is usually included in the county soil survey report. The basic purposes of such a table include the following:

1. It is the simplest and most concise summary of available information about the management of the soils shown on the map.

TABLE 19. SAMPLE SOIL SUITABILITY RATING FOR CROPLAND
(Centre County, Pennsylvania, 1968)

Soils and mapping symbols		Land capability class, sub-class and unit	Limiting factors for cropland	Productivity potential rating for	
				Corn (grain)	Alfalfa
Albrights silt loam	59B2	IIe-15	Slope, seasonal wetness, fragipan	Fair	Fair
	59C2	IIIe-15	Slope, seasonal wetness, fragipan	Fair	Fair
Albrights very stony silt loam	60AB	VIs-36	Stoniness, seasonal wetness, fragipan	--	--
	60CD	VIs-36	Stoniness, slope, seasonal wetness, fragipan	--	--
Allegheny silt loam	26B2	IIe-9	Slope	Good	Excellent
Amaranth silt loam	36B2	IIe-15	Slope, seasonal wetness, fragipan	Fair	Fair
Andover cobbly loam	48B	IVw-24	Cobbliness, slope, high water table, fragipan	Poor	--
	48C	IVw-24	Cobbliness, slope, high water table, fragipan	Poor	--
Andover gravelly loam	47B2	IVw-24	Slope, high water table, fragipan	Fair	--
	47C2	IVw-24	Slope, high water table, fragipan	Fair	--

2. It provides the connecting link between agricultural research and specific tracts of land.
3. The yield predictions under defined sets of management practices provide the basis for using the soil map and report for farm planning, including farm production budgets.
4. It provides a basis for a wide variety of important soil groupings.
5. With it land values can be related to productivity for using the soil map in land evaluation.

The estimated yield predictions are not, of course, hard-and-fast recommendations. Even for different areas of the same kind of soil, different uses are selected by the farmer among the alternatives according to the size of the farm, its location in relation to markets and its other economic characteristics, the capability of the other soils in the farm unit, and the desires, skills, and resources of the farm manager and the family. The soil survey report aims only to inform the farmer concerning what he may expect from the use of certain practices and combinations of practices, both in yields of adapted crops and in the effects they have on the long-time productivity of the soil.

Soil Productivity

Soil productivity is perhaps more an economic concept than it is one of soil science. It is the capacity of a soil for producing a specified plant or sequence of plants under a physically defined set of management practices. It is measured in terms of inputs or production factors in relation to outputs or harvest. Thus soil productivity is not itself an inherent quality of the soil. All the chemical, physical, and biological properties of a soil, together with the associated climate, determine its response to management--response to inputs of labor and materials.

In the United States, a productive soil is generally regarded as one that will give good yields, in relation to inputs of material and labor per acre, when used for a combination of the principal grains and grasses--corn, oats, wheat, clover, and other common crops.

Levels of Management

Yield predictions for a soil type or a phase depend upon management definitions, and the requirements or suggestions for management need to be set against resulting yields. They are intimately related. To have yield predictions for each kind of soil under all significantly different sets of management practices likely to be used by farmers would be ideal. As research in soil classification and on the performance of crops on different kinds of soils progresses, it will be possible to go much further than is feasible today. At least for the present, however, in soil survey interpretation only fairly broad definitions of management can be dealt with. Definition of management practices may be sought at three primary levels--always at level 1, usually at levels 1 and 2, and occasionally at all three--

as listed below. Since the actual sets of practices may vary within any one level, most importance must be attached to their definition.

Level 1--The most common combinations of management practices followed by the majority of successful farmers using the soil being dealt with.

Level 2--The superior combination of management practices followed by the leading farmers using the soil, perhaps 1 percent or perhaps over 10 percent.

Level 3--The optimum combination of management practices developed on pilot-research farms, if any, or on other farms that represent the best (or ceiling) that can be done in the present state of the agricultural arts.

SECTION 10

SITE CONSIDERATIONS FOR RECREATIONAL USES

OVERVIEW

The conversion of mined lands to recreational uses is another alternative that has been gaining popularity in recent years. This increase in the use of mine lands for recreational uses parallels an increasing nationwide demand for outdoor recreation areas, both public and private, that far exceeds existing facilities. This increasing demand for recreational facilities stems from a number of related causes that include (1) a growing population, (2) increase in leisure time, (3) increasing percent of individual incomes available for expenditure on games and sports, (4) an improving technology, and (5) the increasing cost of land close to urban centers (Clawson et al., 1960; Pickels, 1970). It is anticipated that in the near future many more areas now dedicated only to forestry or grazing will be converted to recreational uses (Pfleider, 1968).

This section reviews the site considerations related to recreational uses. It presents a discussion of the major types of recreational uses and emphasizes those that have found the greatest application on mined lands. The site considerations are grouped under the two general headings, previously introduced, that consist of cultural factors and natural factors. The materials presented in this section were developed from two principal sources. The first is a "Guide to Making Appraisals of Potentials for Outdoor Recreation Developments" prepared by the U.S.D.A. Soil Conservation Service (SCS, 1966). The other is a report titled, "Realizing the Recreation Potential of Sand and Gravel Sites," prepared by G. Pickels of the University of Illinois under sponsorship of the National Sand and Gravel Association (Pickels, 1970).

CLASSIFICATION OF RECREATION TYPES

A common method of classifying recreation areas consists of designating the area as one of three types: (1) resource-oriented, (2) user-oriented, or (3) intermediate--a combination of the first two. A description of these types as presented by Pickels (1970) is provided below.

Resource-Oriented

Resource oriented recreation facilities are those facilities that are considered to possess scenic, scientific, or historic significance. Scenic areas are characterized by picturesque vistas, overlooks, drives, and unusual natural features such as waterfalls, mountains, or rivers. Scientific sites exhibit unique geologic or biological features of significant educational value, such as fossil beds, unique rock formations, and volcanoes, where natural phenomena can be studied. Historic sites are those that reflect significant previous use, character, or individuality, either of the site or of some specific feature upon it, such as important battle sites, archeologic features, and unique historic structures.

Surface coal mine lands may be utilized in conjunction with development of either scenic or scientific areas. Contour mining methods that are used in steep terrain can be converted into viewing observatories if the views obtained from these areas are considered to possess scenic qualities. Also, because of the nature of the substrata, the mine highwall may lay open to view various layers of geologic material that holds scientific value, both to the professional and to the amateur geologist. Historic sites, however, are not compatible with surface coal mining operations and their occurrence will prohibit mining and most other surface disturbances of that site.

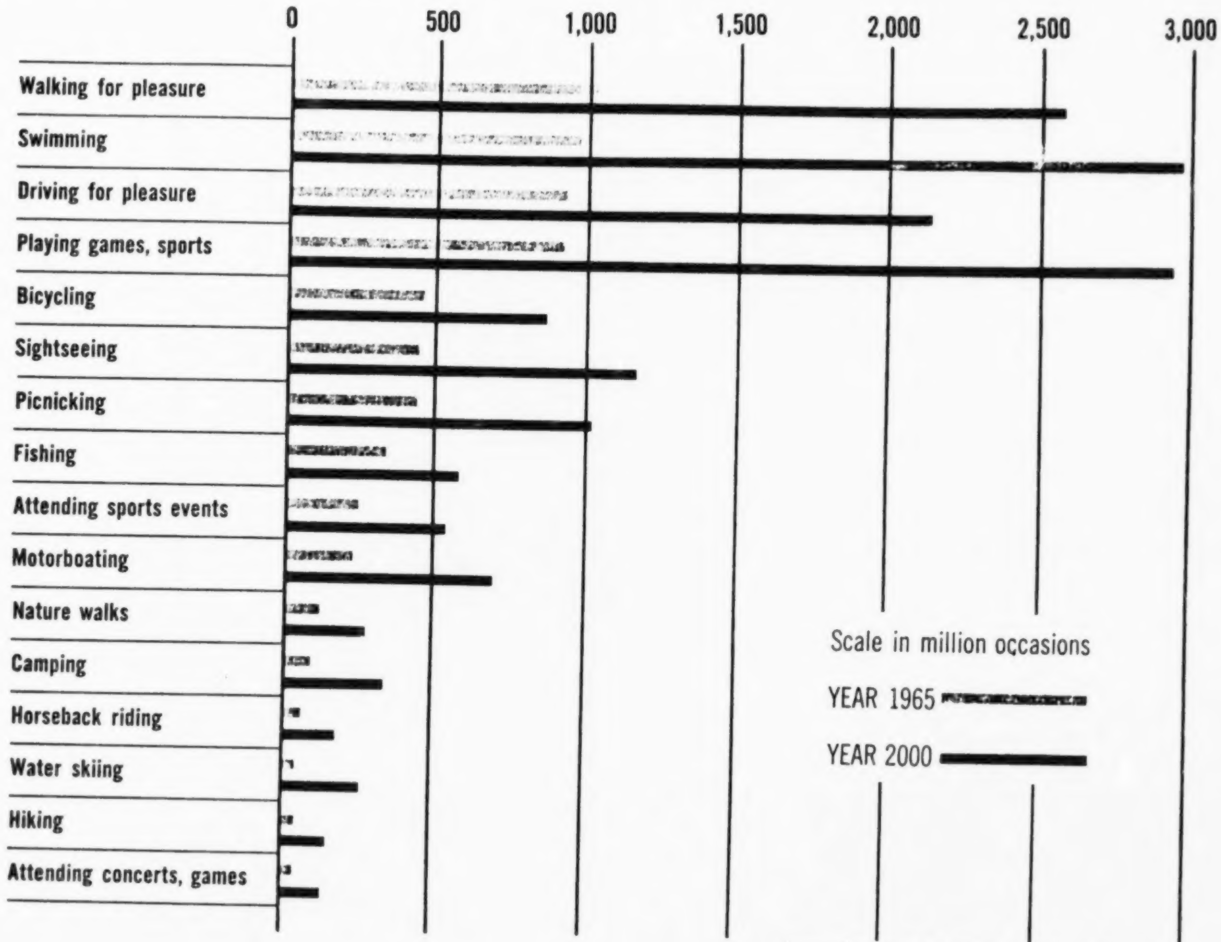
User-Oriented

A recreation area that is primarily oriented towards providing activities for a large number of people is a user-oriented area. Such areas are characterized by numerous and varied recreation use. Urban parks (neighborhood, community, district) are prime examples of user-oriented facilities. These recreation facilities are usually located in proximity to potential users and serve a specific area. They are considerably smaller than resource-oriented parks and are generally not noted for their resource value. All user-oriented parks are not entirely devoted to the pursuits of children. Recreation use areas are basically divided into two types--active and passive. This arrangement provides a varied recreation program that is necessary in a highly populated area where interests are as varied as the types of people. Figure 32 lists the most popular summertime outdoor recreation activities.

Surface coal mining operations located near urban areas are well suited for this type of development. The lakes created by the final cuts in the mined areas of the Midwest have produced some of the best water for recreational purposes. These lakes provide excellent fishing, swimming, and water sports areas. Reclaimed lands adjacent to these lakes are in great demand for the construction of summer homes and for permanent homesites. One large complex, including an 18-hole golf course, clubhouse, and homesites, was developed in west-central Illinois.

Intermediate

Intermediate recreation areas, a combination of resource-user-oriented areas, are usually smaller than the large resource-oriented areas. They are exemplified by some state parks and by U.S. Corps of Engineers' reservoir projects that are generally within two hours driving time of their users. They exhibit features that attract both the resource-oriented and the user-oriented recreationist.



Information by U.S. Bureau of Outdoor Recreation

Figure 32. Most popular summertime outdoor recreation activities (Pickels, 1970).

The majority of surface coal mined lands could be classified in the user-oriented and composite resource-user-oriented park categories, depending on the size and location of the operation. Extensive use is being made of these mined areas within 100 to 150 miles of population centers. The demand for building sites and recreation areas has developed so much that it now exceeds the supply of available sites.

Park Classification

The term park is frequently used generically and applied to many different kinds of areas. Most of the states use a number of classifications based upon considerations such as character, use, custom, and statutory requirements. These vary from state to state, and more than 60 classifications are currently in use. In addition there are extensive public areas reserved for purposes other than recreation but that also offer recreation opportunities. In formulating recommendations to establish such public or private areas, it should fall under one of the classifications adopted by federal, state, and local agencies.

Attempts have been made to simplify the classification of recreational facilities into one of four major groupings which include (1) neighborhood parks, (2) district parks, (3) community parks, and (4) special park areas. Tables 20, 21, and 22 present in a summary form a number of the essential planning criteria for recreational activities and facilities, including space requirements, location and service radius, and population served (Dechiara and Koppelman, 1968).

INFLUENCE OF CULTURAL FACTORS ON RECREATIONAL LAND USE

The cultural factors previously discussed in Section 4 play an important role in determining the suitability of a site for recreational use. The factors that have the greatest bearing include location and proximity to population centers, accessibility of the site, size and configuration of the site, and existing and surrounding land uses.

Location and Access

All recreation activities are distance-related. This usually means the distance from the urban center where the user lives to the recreation area, measured by miles or hours. Hence, the distance of the recreation area from its source of clientele is important in varying degrees depending upon the kind of development. This proximity for purposes of outdoor recreation is measured almost wholly by the public road system.

The classification of a recreation area often has a direct bearing upon its location. The larger recreation areas, such as the resource-oriented areas, are generally not within walking distance and usually lie beyond the limits of transportation lines. In order to adequately serve large urban centers, these recreation facilities have to be located along or adjacent to major traffic routes or reasonably close by. Since the location alone of access routes does not dictate where a park is to be sited, provisions may

TABLE 20. GENERAL STANDARDS FOR MAJOR RECREATION FACILITIES (Dechiara and Koppelman, 1968)

Facility	Standard	Remarks
Arboretum	one per region*	develop according to interest
Arena		
Artificial ice area--indoor	one per 20,000	one in each municipality should have seating capacity for league games; the rest should be for recreation purposes
Artificial ice area--outdoor	can be built in place of indoor facility	may serve as a summer play area
Natural ice--outdoor	one per 5,000	used only where normal weather conditions allow two or three months of use
Athletic field	one per 20,000	in a community† park or combined with secondary school
Beach areas	each municipality should develop all potential beach areas	now considered an essential recreation area
Botanical gardens	one per region	best when linked to an educational institution
Camping Areas		
Day camp--	to accommodate a minimum of 100 children; at least one location for each 25,000	an isolated area; often found in a conservation or regional park; maximum capacity per unit or for one director is 120 children
Family--	one acre per 5,000	for family or short term camping; located in regional park or conservation area
Resident--	one per 40,000; should serve at least 100 persons	often provided by private agencies
Centers		
Civic--	one per 100,000	could include some or all of the other centers
Community--	one per 25,000	a multi-purpose building; should be part of secondary school or located in a community park

(continued)

TABLE 20. (continued)

Facility	Standard	Remarks
Fishing area	one per region	controlled and stocked for public use
Golf courses		
Regulation--	18 holes for 50,000	minimum of 120 to 180 acres
Library	one per 20,000	additional branches added as required; should include a bookmobile service for suburban areas
Marina	one per suitable watercraft area	size according to need and potential
Museum	one per region	may differ in emphasis--i.e., science, historical, etc., should grow with the population
Nature & hiking trails	as many as possible	develop according to interest; usually in a regional park
Outdoor theatre	one per region; seat between 1,000 & 10,000	a natural amphitheatre or large structure to accommodate drama, music and films; developed according to interest; interest may require small intimate theatres in neighborhood# parks
Picnic Areas	one acre for each 3,000 to 5,000	usually in regional park or conservation area; enhanced by water frontage or view
Pools		
Major indoor--	one per 50,000	should include competitive and spectator facilities
Outdoor-indoor--	one per 20,000; to accommodate 2½ to 3% of population at one time; min. capacity of 200 per pool using 27 sq. ft. per swimmer	should be located in community or in conjunction with secondary school. These should be built wherever possible in place of outdoor pools
Outdoor--	one per 10,000	deck size twice the size of the water surface; often built as part of a multi-purpose unit in a community park; the second one not considered until after 25,000 is reached

TABLE 20. (continued)

Facility	Standard	Remarks
Pools		
Spray--	one per 5,000	must be on paved surface with ample drainage
Training--	one per 5,000	required no diving area
Riding Trails	one per region	can be developed in a regional park or conservation area
Sanctuaries (bird or animal)	one per region	should contain shelter and feeding facilities
Skiing		
Snow--	one per region	developed according to suitability of area; should contain shelter, tow, jumps, snow making machine; could be part of golf course or nature trail. Include beginners, intermediate, advanced and family slopes
Water--	one per region	safe, controlled water area
Stadium or bowl	one per 100,000	a major multi-purpose sports field with flood lighting, dressing rooms, wash rooms, food concessions and parking for professional or highly organized team sports
Track & field	one per 20,000	usually part of an athletic field; secondary school or sports stadium; each secondary school should have practice areas
Zoo or zoological gardens	one well developed unit for each 250,000 to 500,000 people	should start with 50,000 people and grow with population

* A region will contain about 60,000 people.
† A community will contain about 25,000 people.
# A neighborhood will contain about 5,000 people.

TABLE 21. STANDARDS FOR RECREATIONAL ACTIVITIES (Dechiara and Koppelman, 1968)

Type of recreational activity	Space requirements for activity per population	Ideal size of space required for activity	Recreational area wherein activity may be located
Active Recreation			
1. Children's play area (with equipment)	0.5 acre/1,000 pop.	1 acre	Playgrounds-neighborhood parks, community parks, school playgrounds
2. Field play areas for young children	1.5 acres/1,000 pop.	3 acres	Playgrounds-neighborhood parks, community parks
3. Older children-adult field sports activities	1.5 acres/1,000 pop.	15 acres	Playfield-community park, district park
4. Tennis-outdoor basketball, other court sports	1.0 acres/5,000 pop.	2 acres	Playfield-community park
5. Swimming	1 outdoor pool/25,000	Competition size plus wading pool 2 acres	Playfield-community park
6. Major boating activities	100 acres/50,000	100 acres & over	District park, regional park, or reservation
7. Hiking, camping, horseback riding, nature study	10 acres/1,000 pop.	500-1,000 acres	Large district park, regional park
8. Golfing	1-18 hole course per 50,000 pop.	120 acres	Community park, district park

(continued)

TABLE 21. (continued)

Type of recreational activity	Space requirements for activity per population	Ideal size of space required for activity	Recreational area wherein activity may be located
Passive recreation			
1. Picnicking	4 acres/1,000 pop.	varies	All parks
2. Passive water sports-fishing, rowing, canoeing	1 lake or lagoon per 25,000 pop.	20 acre water area	Community parks, special regional reservations
3. Zoos, arboretums, botanical gardens	1 acre/1,000 pop.	100 acres	Large district park or special facility
Other			
1. Parking at recreational areas	1 acre/1,000 pop.	varies	Playfields, community, district & regional parks
2. Indoor recreation centers	1 acre/10,000 pop.	1-2 acres	Community parks
3. Outdoor theaters, band shells	1 acre/25,000 pop.	5 acres	District parks

TABLE 22. STANDARDS FOR RECREATIONAL AREAS (Dechiara and Koppelman, 1968)

Type of area	Acres per 1000 population	Size of site Ideal	Size of site Minimum	Radius of area served
Playgrounds	1.5	4 acres	2 acres	0.5 miles
Neighborhood parks	2.0	10	5	0.5
Playfields	1.5	15	10	1.5
Community parks	3.5	100	40	2.0
District parks	2.0	200	100	3.0
Regional parks and reservations	15.0	500-1000	varies	10.0

have to be made for the construction of adequate connector routes that link the park with major acess routes. Table 22 provides some general criteria for the radius of area served by park facilities ranging from playground to regional parks.

Extensive use is currently being made of mined areas within 150 miles of population centers. Private clubs are utilizing all of the available mined acreage within 60 miles of Chicago. In Indiana all available building sites within approximately 100 miles of Indianapolis are in such heavy demand that the price those areas are commanding now exceeds the price the mining companies paid for the land when they acquired it for coal. The distance travelled by people seeking outdoor recreation opportunities is constantly increasing (Pfleider, 1968)

The data needed to rate the proximity and access elements may be obtained from county and state road maps and from the U.S. Census. This data may need to be interpreted with help from the local highway officials and with the experienced judgment of the appraising team. A map of the county and surrounding counties should be obtained that shows:

(a) The all-weather roads. These are the Federal-state numbered roads plus the all-weather local roads suitable for recreation traffic. Generally excluded from this definition are: dirt roads; all gravel roads other than well-maintained, wide roads equal to good hard-top roads; poor hard-top, farm-to-market types of roads.

(b) The portions of the all-weather roads that may be classed as important tourist routes. These are the highways, usually in the Federal-state numbered system, that carry large volumes of tourist (that is, recreation) traffic in the tourist season. This traffic is the nonlocal, mostly out-of-state, vehicles for which highway people often have data. Limited-access tourist routes should be counted only for the portions that actually serve areas in the district.

(c) The urban centers of 5,000 to 20,000 size.

(d) The urban centers of 20,000 and larger.

Measurements are made on this map to give:

(a) The miles of all-weather roads.
(b) The miles of important tourist routes.
(c) The miles of all-weather roads that are within 20 road miles of urban centers of 5,000 or more.
(d) The miles of all-weather roads that are within 40 road miles of urban centers of 20,000 or more.
(e) The miles of all-weather roads that are within 20 road miles of urban centers of 20,000 or more.

Another map of the county with the adjacent counties and the area up to a day's drive away is needed. The Selected Distance Urban Centers (S.D.U.C.) are placed on this map and circles drawn from the center of the district at the 50 mile, 150 mile, and 300 mile (or a day's drive) zones. The proportion of the S.D.U.C.'s that are in the 50-150 mile zone has special significance. The location of inventoried natural, scenic, and historic areas are placed on a copy of the first map. The number and percentage of these that have access is determined. Access to a natural area is a road reaching the edge of the area, and each such point is considered to serve that part of the area reachable on foot in one hour. Large wilderness areas are exceptions and require less access for their special kinds of use. Scenic area access is a road within good view of the area. Access to historic areas is a road to the site. The locations of potential winter sports areas are placed on the map. The number and percentage of these that have an all-weather road to the base (or top) of the site is determined.

The degree of access of the whole area of the district can be gauged by determining the portion that is within one mile of an all-weather road and the parts of this total that are close to population centers.

Size and Configuration

The size and configuration of recreation areas are dependent upon many different factors as illustrated in Figure 33 (Pickels, 1970). Within designated recreation areas certain specific uses can be programmed, depending upon the physical requirements of the specific use. Length and width dimensions determine the siting and subsequent occurrence of a particular use. Though most active recreation use areas (for court and field games) are rectangular in design, irregular sloped parcels of land should not be considered lost space. Parking lots, passive recreation areas, and buffer zones make good use of such areas.

Size may directly affect the classification and the manner in which a recreation area is to be utilized. Table 22 lists some common recreation activities and types along with their size requirements.

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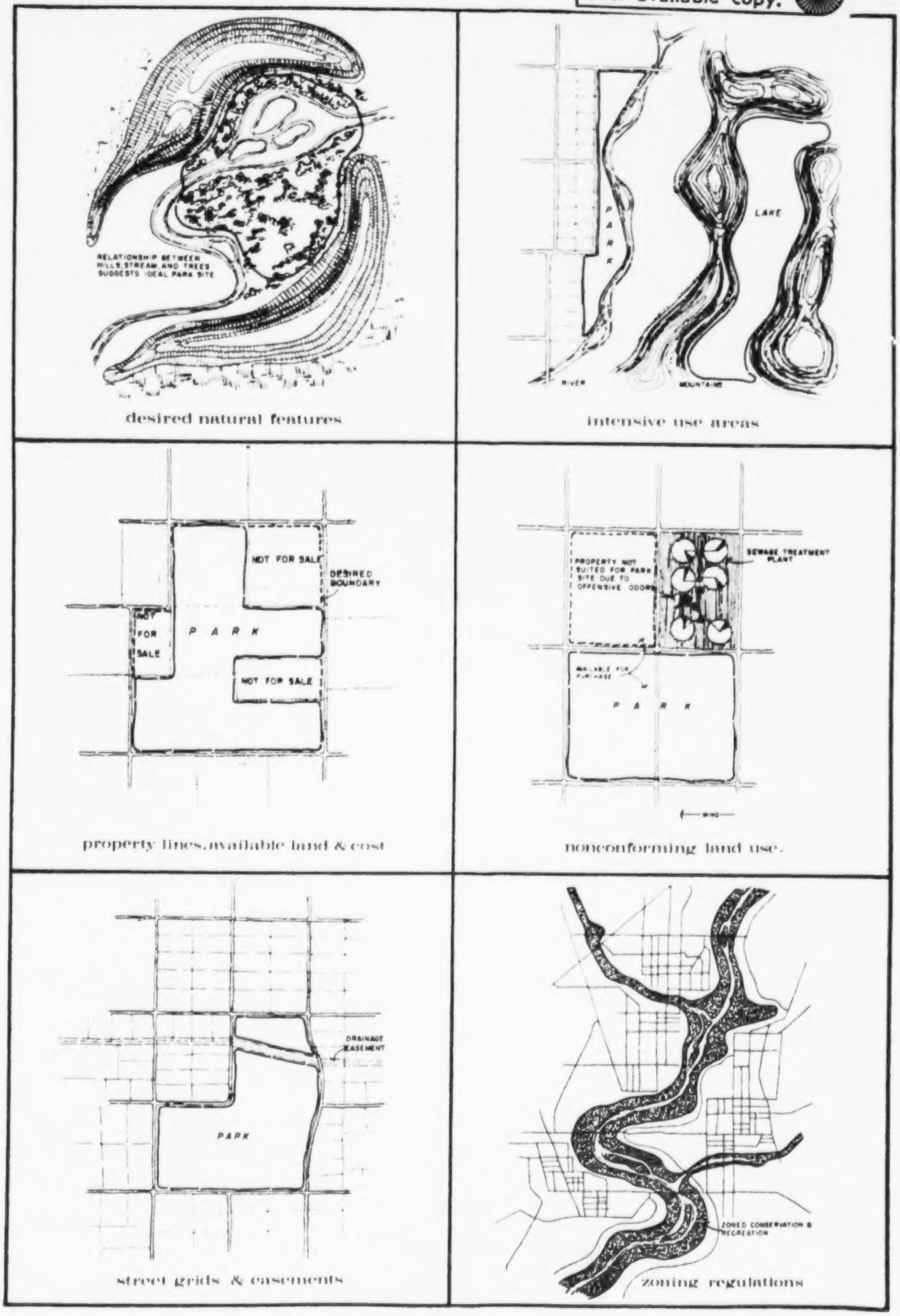
RELATIONSHIP BETWEEN
HILLS, STREAM, AND TREES
SUGGESTS IDEAL PARK SITE
desired natural features
PARK
LAKE
RIVER
MOUNTAINS
intensive use areas
NOT FOR SALE
DESIRED BOUNDARY
NOT FOR SALE
PARK
NOT FOR SALE
property lines, available land & cost
PROPERTY NOT SUITED FOR PARK SITE DUE TO OFFENSIVE ODORS
SEWAGE TREATMENT PLANT
AVAILABLE FOR PURCHASE
PARK
WIND
nonconforming land use.
DRAINAGE EASEMENT
PARK
street grids & easements
ZONED CONSERVATION & RECREATION
zoning regulations

Figure 33. Size and configuration of determinants of recreation areas (Pickels, 1970).

Surface mining operations vary in size and configuration based principally on the nature and extent of the coal deposit, the existing surface topography, and the nature and depth of overburden. These factors were previously discussed in Section 4.

Surrounding Land Uses

Although not an onsite configuration, adjacent land uses may place a limiting constraint on the suitability of a site for recreational use. Annoyance factors, such as noise, dust, water, air pollution, and unsightly views, may not only influence siting of various uses, but may also eliminate a portion of the site from recreational use. Such problems may be partially or totally eliminated through the use of screening elements (earthen mounds and plantings) and in the orientation of major use areas.

INFLUENCE OF NATURAL FACTORS ON RECREATIONAL USE

The natural factors that have been discussed under the three groupings of climate, geomorphology, and soils (Sections 5, 6 and 7 respectively) play an important role in determining the suitability of a mine site for recreational use.

Climate

Aspects and seasonability of the climate as they affect various recreation activities and enterprises should be appraised as either a contributing key element or limiting factor. Climate may be contributing to some types of activities and limiting to others in the same area. Seasonal temperature, precipitation patterns, sunshine, and snowfall may be important in various combinations. It is important to appraise climate as a relative matter for many situations, comparing local climate to the climate where the recreationists live. Long-term averages should be obtained for the following parameters:

1. Percent of possible sunshine-average for pertinent months and seasons;
2. Temperature-average mean by months; number of winter season days between first and last occurrence of 16°F or colder; and
3. Precipitation-average for year and by months; average snowfall for a year.

Most of this data is provided in Volume 3. Table 23 presents a summary discussion of the climatic considerations related to various recreational uses.

Geomorphology

Topography and Slope--

Topographic features are among the most functional aspects of a recreation landscape. They not only have strong aesthetic qualities, but the type of feature can have a direct effect upon the type of recreational uses

TABLE 23. CLIMATIC CONSIDERATIONS FOR RECREATIONAL USES (SCS, 1966)

Recreational activity	Climatic considerations
Vacation cabins, cottages, homesites	The climate element as applied here relates to its desirability for vacationing purposes. It should be judged in relation to the climate in surrounding areas where the potential clientele are expected to come from. It may also be desirable to judge it separately for popular vacation seasons, usually summer and winter. Favorable aspects of climate for vacationing are lots of sunshine, no protracted rainy periods, cool summer night temperatures, warm winter temperatures, and low humidity. A zone of up to a day's drive outside the county is likely to be the area from which most vacationing clients would come. The climate in the country (or particular parts of it) must be significantly better for vacationing than the climate in the urban centers of the outer zone. Guidance in judging the climate element may be obtained by comparing U.S. Weather Bureau data for areas of the county thought to be suitable for vacation cabins, cottages, etc. with that for the urban centers likely to supply the clientele. Substantial favorable differences in the county figures compared to those of the urban areas would warrant a high rating. If the climate in the county is definitely unfavorable for outdoor vacationing, it would be a limiting factor.
Camping grounds	Climate is very important in camping grounds' potential, particularly for vacation site and pack trip types. It is often very seasonal with cooler areas favored in summer and warmer areas in winter. Since vacation camping is predominantly a family activity, the cool summer areas have the greater opportunity. The source of clientele for camping is a wide area, larger than that for vacation cabins, cottages, and homesites, though the popularity of short, weekend camping trips must be distinctly favorable for outdoor living, except for the transient type area. Pleasantly warm days with cool nights is the needed combination. This favorable climate should span the school vacation period--June, July and August. In some areas, other periods are equally or more significant. The same analysis of U.S. Weather Bureau data that was used for vacation cabins will serve for the transient type. The climate in the areas of the county having other favorable attributes for camping must be distinctly better than that in the localities where the potential clientele come from.

(continued)

TABLE 23. (continued)

Recreational activity	Climatic considerations
Picnic and field sports area	Climate locally affects both bicycling and picknicking. The comparison to be made is between the factors of climate--temperature and clarity of air, primarily--in the urban areas and in the nearby rural areas. Relatively small differences are significant if they apply during the daytime and early evening. If the temperature is ten degrees less at the activity area than in the city, if there is a fairly dependable breeze as compared with the dead summer air in town, if the air is free of smoke and other pollution, these advantages are to be appraised to rate the local climate for these activities. Local knowledge rather than published U.S. Weather Bureau data may be used to judge this element. Climate may limit activities on game, play, and target areas at some seasons. Extremes of temperatures and depth of snow are the most likely limiting conditions. Where year-round use of such areas is limited by climate conditions, the top rating should be reduced a point for each month as limited. Local U.S. Weather Bureau data will help in judging this limitation.
Fishing waters	Climate affects fishing waters' potential in several ways. First, it has a bearing on the species of fish encountered. Cold-water fishing concerns fishing for various species of trout and salmon. All other fishing is warm water fishing. Seasons suitable for fishing depend upon climate. Fishing comfort and the effect on the desires of fishermen is largely a matter of climate. These matters should be appraised in terms of their effect on potentials for increasing fishing interest in the county.
Hunting areas	Climate affects the usefulness of an area for hunting because it either facilitates or impedes the hunters' mobility and comfort and because it affects the degree of activity on the game. The influence of climate on productivity and mortality of game is also important. Unless there are particular, prevalent conditions that would discourage hunters from pursuit of local game, such as excessive cold, heat, rain, or snow, the rating on this element would be high.
Riding stables	Climate has some influence on the potential for horseback riding enterprises. Areas with open winters and relatively little snow and those with a large number of sunny days are favored.

(continued)

TABLE 23. (continued)

Recreational activity	Climatic considerations
Shooting preserves	Climate has a general influence on the suitability of areas for shooting preserves. However, since the shooting activities are limited to the fall and winter months, the primary importance of climate is in the most northern states. Here the winters set a restrictive term to the period of customer interest and activity. In the coldest and snowiest sections, this element becomes a limiting factor. Since most of the business comes on weekends (and some states will not permit Sunday operation), there must be a long enough season of good weather to permit an adequate volume of business to justify the enterprise. Hence, climate is most significant as a limiting factor. Otherwise, it may be rated in terms of the prevalence of pleasant bird hunting weather from September through March.
Vacation farms and ranches	Climate is a very important consideration for location of vacation farms and ranches. The climate during the vacation periods must be attractive for the time of year. It must be a favorable change from that in the urban areas where the potential clientele come from. Unless parts of the country have distinctly favorable climate, it can be a limiting factor. A top rating would apply to farming or ranching areas situated in recognized vacation country--frequently associated with high elevations (for summer), warm days, cool night temperatures, and lots of sunshine.
Water sports areas	Climate may limit the season of use of waters and render waters unsuited for swimming in cold regions. The degree to which these limitations apply should be reflected in the rating.
Winter sports areas	Climate for good winter sports area potential must have long winters, a large number of below-freezing days, and snowfall that is frequent and substantial. These characteristics of the climate need be judged only for specific locations in the county that are otherwise

(continued)

TABLE 23. (continued)

Recreational activity	Climatic considerations
Winter sports areas (continued)	feasible for winter sports. In most areas, these will be locations in the coldest and snowiest sections. A season of 120 days or more is needed for economical operation. This period may be measured from the date of the first 16°F temperature in the fall to the last one in the spring. Ratings for both temperature and snowfall should be made and then averaged. Where either temperature or snowfall fails to meet the minimum conditions, climate becomes a limiting factor. Inadequate natural snowfall can be augmented with artificial snow machines, but this installation requires a high potential of use for economic justification. It should be noted that the lower ranges of acceptable temperatures and snowfall would apply to developments that are local in scope. Winter sports areas designed for widespread appeal and tournament activity would need a very high climate rating.

incorporated onto a particular site. Hills suggest hiking, climbing, and winter activities. Northeast and northwest slopes provide shelter from sun and wind, while flat areas may be easily utilized for camping facilities or building sites. Aesthetically, land forms of varying height and configuration can define space, reduce scale, provide privacy and solitude, suggest natural circulation of walkways, paths and roads, channel or restrict views, and define use areas.

Drainage and Water Features--
Drainage and water features are important elements in determining the suitability of a mine site for recreational use. Traditionally, water features of various types have captured the imagination of people in all walks of life. Water can be made to flow, gurgle, gush, seep, slide and stand depending upon the effect one desires to achieve. Aesthetically, water in various degrees of motion and confinement can portray moods of serenity, strife, anticipation, or anger. Functionally, water can provide a place to swim, fish, or boat. Recreational use of water areas depends primarily upon the depth of the water, amount of shore frontage, water clarity and cleanliness, and nature of the shore area. In situations where it is possible to alter shorelines and create various land configurations, the type of recreation uses to be incorporated onto the site should strongly suggest how this is to be accomplished.

Soils

A knowledge of soils is essential in selecting sites for various outdoor recreational development. Soil conditions are of significance primarily in specific site planning. However, for some kinds of developments, wide-spread soil conditions may be important in appraising potentials over considerable areas.

The county soil survey report, when available, provides important recreation interpretations of the key soils in the district that show soil limitations for various recreational uses. Table 24 is a sample soil evaluation for components of recreational development. Each soil is rated for recreational uses in terms of the degree of limitation--slight, moderate, or severe. The degree of limitation indicates the severity of the problems expected to be encountered for the specified use. Major limiting factors are also listed when the soil has a moderate or severe rating. The three degrees of limitation are defined as follows:

1. Slight--These soils have few known limitations for the use indicated.
2. Moderate--These soils have one or more properties that limit their use. Correcting these factors will increase the installation and maintenance costs.
3. Severe--These soils have one or more properties that seriously limit their use. Using soils with a severe limitation will increase the probability of failure and add to the cost of installation and maintenance.

TABLE 24. SAMPLE SOIL EVALUATION FOR COMPONENTS OF RECREATIONAL DEVELOPMENT
(Centre County, Pennsylvania, 1968)

Soils and mapping symbols	Camp sites		Service buildings in recreational areas (without basements)	Paths and trails in camping areas	Picnic and play areas (extensive use)	Athletic fields (intensive use)	Golf fairways
	Tents	Trailers					
Albrights 59B2 silt loam	Moderate--Seasonal high water table	Moderate--Seasonal high water table, slope	Slight	Moderate--Surface texture	Slight	Moderate--Seasonal high water table, slope	Slight
59C2	Moderate--Seasonal high water table, slope	Severe--Slope	Moderate--Slope	Moderate--Surface texture, slope	Moderate--Slope	Severe--Slope	Moderate--Slope
Albrights 60AB very stony silt loam	Moderate--Seasonal high water table, stoniness	Moderate--Seasonal high water table, stoniness, slope	Slight	Moderate--Surface texture	Slight	Moderate--Seasonal high water table, stoniness, slope	Moderate--Stoniness
60CD	Severe--slope	Severe--slope	Moderate--Slope	Severe--Slope	Severe--Slope	Severe--Slope	Severe--Slope
Allegheny 26B2 silt loam	Slight	Moderate--slope	Slight	Moderate--Surface texture	Slight	Moderate--Slope	Slight
Amaranth 36B2 silt loam	Severe--Slow permeability	Severe--Slow permeability	Slight	Moderate--Surface texture	Slight	Severe--Slow permeability	Slight

(continued)

TABLE 24. (continued)

Soils and mapping symbols	Camp sites Tents	Camp sites Trailers	Service buildings in recreational areas (without basements)	Paths and trails in camping areas	Picnic and play areas (extensive use)	Athletic fields (intensive use)	Golf fairways
Andover cobbly loam 48B	Severe--Coarse fragments, high water table	Severe--Coarse fragments, high water table	Severe--High water table	Moderate--High water table	Severe--High water table	Severe--Coarse fragments, high water table	Severe--Coarse fragments, high water table
48C	Severe--Coarse fragments, high water table	Severe--Coarse fragments, high water table, slope	Severe--High water table	Moderate--High water table, slope	Severe--High water table	Severe--Coarse fragments, high water table, slope	Severe--Coarse fragments, high water table
Andover gravelly loam 47B2	Severe--High water table	Severe--High water table	Severe--High water table	Moderate--High water table	Severe--High water table	Severe--High water table	Severe--High water table

The decision as to whether or not a soil will be used for a specific purpose, regardless of the limitation, is beyond the scope of this information. At a price, almost any limitation can be overcome. The information contained in Table 24 will be valuable in planning more detailed field surveys to determine the in-place condition of the soil at the site.

Soil properties considered in rating soils for recreational development include depth to bedrock, depth to seasonal high water table, slope, surface texture, stoniness, and frequency of flooding. Each property affects the way a soil will respond to a specific recreational use. Information presented in the table should be used for screening sites for more detailed onsite investigations. The seven components of recreational development rated in the table are discussed below.

Tent and Trailer Camp Sites--

These soil ratings apply to areas suitable for tents with platforms and small trailer camp sites and the accompanying activities for outdoor living. These areas are used frequently during the camping season that normally extends from May 30 until Labor Day. The soils are rated assuming little site preparation other than shaping and leveling tent and parking areas. The site should be suitable for heavy foot traffic by humans, horses, or vehicular traffic. Suitability of soil for supporting vegetation is a separate item to be considered in the final evaluation of selecting sites for these uses.

Buildings Without Basements--

These soil ratings classify a soil according to limitations for use as building sites for seasonal and year-round cottages, washrooms and bathhouses, picnic shelters, and service buildings without basements.

Paths and Trails--

This soil rating applies to areas that are to be used for trails, cross-country hiking, bridle paths, and nonintensive uses that allow for random movement of people. It is assumed that these areas are to be used as they occur in nature with little soil moved (excavated) for the planned recreational use. Areas such as swamps, marshes, peat bogs, sand dunes, etc. are considered to have very severe soil limitations.

Picnic and Play Areas--

These soil ratings apply to areas to be developed for hiking, picknicking, and casual play where only light foot traffic is expected. The ratings are based on soil features only and do not include other features, such as the presence of trees or lakes, that may affect the desirability of a site. Suitability of soil for supporting vegetation is a separate item to be considered in the final evaluation of selecting sites for these uses.

Athletic Fields--

These soil ratings apply to areas to be developed as playgrounds for organized games such as baseball, football, badminton, etc. Areas selected for this use are subject to intensive foot traffic; therefore, a nearly level surface, good drainage, and a soil texture and consistence that gives a firm surface are generally required. The most desirable soils are also free of rock outcrops and coarse fragments. It is assumed that good vegetative cover can be established and maintained on areas where needed.

Golf Fairways--

The soils are rated for this use assuming they will be used for turf, shrubs, and trees without adding topsoil. Traps, roughs, and greens are specialized features not considered in ratings for golf fairways.

SECTION 11

SITE CONSIDERATIONS FOR COMMUNITY DEVELOPMENT

OVERVIEW

The opportunity to reclaim a mine site to residential and related land use has been somewhat limited in the past. There is some evidence which indicates that the two primary constraints to this type of reclamation, namely location and demand, are rapidly diminishing, particularly in Appalachia. The numerous examples of commercial, residential, institutional, and industrial land uses of reclaimed surface mines in West Virginia listed in Table 1 of Section 2 clearly illustrate this trend.

Community development refers to the planning and integration of a variety of urban-oriented land uses that include residential uses; a number of public or institutional uses such as schools, parks, utilities, etc., as well as a mixture of commercial and possibly industrial uses. This section examines the site considerations associated with a number of these elements of community development. Specifically, the discussion will focus on the development of residential, educational, and transportation facilities. Though commercial and industrial land development will not be directly addressed, many of the site considerations of residential and institutional development are applicable to the former uses.

RESIDENTIAL LAND DEVELOPMENT

The decision to develop a parcel of land for residential use must be based on a careful examination of the compatibility of the existing market and site condition. Figure 34 provides a comprehensive checklist of a number of factors that influence the site selection process. In the discussion that follows a number of these factors will be addressed. The discussion is structured around the four major classes of factors introduced in Sections 4 through 7--geography, climate, geomorphology, and soils.

Literature related to residential land planning and development is readily available. Consequently, the materials presented in this section have been derived and abstracted from numerous sources. Since the amount of coverage that can be provided in this report is limited, the reader looking for more detailed information on this topic should consult the following references from which these materials are derived: ULI, 1968; ASCE, 1969, Rubenstein, 1968; and Dechiara and Koppelman, 1968.

Site ____

Size _____________________________________ Acres ____

Location Factors

Direction from city ______________________________

Class of surrounding development:

high ____________ medium ____________ low ____________

Distance from central business district ______________

via ____ street

Distance from major employment centers ______________

Public Transportation: type ______________________

good ____________ fair ____________ poor ____________

Fare to employment & center ______________________

Travel Time ______________________________________

Automobile access:

good ____________ fair ____________ poor ____________

Travel time to employment and center ______________

Type of highway approaches:

good ____________ fair ____________ poor ____________

Presence of Community Facilities

Existing shopping center or stores:

Size and type ____________________________________

Distance ____

New center feasible: yes ______________ no ______________

Size of tributary area ___________________________

Schools:

Elementary ______________________ distance __________

High School _____________________ distance __________

Nursery Schools _________________ distance __________

Churches:

Number ____

Denominations ____________________________________

Distances ____

Recreation: Name Distance

Parks ____

Playgrounds ______________________________________

Other ____

Other facilities such as library, colleges, etc. __________

Environment Factors Tract Surrounding Area

Zoning ____

Private Covenants ________________________________

Subdivision Regulations __________________________

Surrounding development: kind ____________________

good ____________ fair ____________ poor ____________

Tract abuts heavily travelled thoroughfare:

Yes ______________ No ______________

Prevailing wind __________________________________

Industrial smoke: yes ______________ no ______________

Figure 34. Checklist for subdivision site selection (ULI, 1968).

Airports:
    Distance ____________________
    Relation to approaches ____________________
Airparks:
    Distance ____________________
    Relation to approaches ____________________

Site Factors
Raw Land Price ____________ per acre. Total ____________
Public Water Supply Connections: yes ____________ no ____________
Distance and size of nearest main ____________________
Will require - independent system ____________________
Individual wells ____________________
Public Sewer - connections: yes ____________ no ____________
Distance, size and invert of nearest main ____________________
____
Will require - independent system ____________________
Septic tanks ____________________
Topography: hilly ____________ level ____________ rolling ____________
Elevation of site:
Highest point ____________ Lowest point ____________ Average elevation ____________
Estimated amount of land over 8% slope ____________________
Elevation with relation to existing streets:
    above grade ____________ below grade ____________
Heavy grading needed:
    for streets ____________ for lots ____________
Swamp areas ____________ pockets ____________
Type of soil ____________________
Rock outcrop or depth of soil cap ____________________
Heavy woods ____________ scrub ____________ open ____________
Type of development indicated by check list:
    Single Family Detached ____________________
    Group ____________________
    Row ____________________
    Garden apartments ____________________
Small Shopping Center ____________________
Other ____________________
Large Lots required - estimated size ____________________
Price range indicated by survey ____________________
Current Market Demand ____________________
Rating of site for various uses: ____________________
Are indicated uses permitted by zoning or covenants? ____________________
Remarks ____________________
____
____

Figure 34. (continued)

EDUCATIONAL FACILITIES

Educational facilities are required for all communities. These educational facilities include the following types of schools:

1. Nursery school,
2. Elementary school,
3. Junior high school,
4. Senior high school,
5. Junior college,
6. College, and
7. Special schools.

Several basic items of information are required to plan for future school facilities. They are (1) population characteristics and growth projection, (2) land use projections, (3) inventory of present facilities with regard to capacity, condition, and location, and (4) standards of design, space, and location. The discussion of educational facilities is grouped together with residential and utilities development. The major emphasis is placed on location and space requirements for schools.

TRANSPORTATION FACILITIES

Transportation facilities, together with sewage disposal, storm sewerage, water distribution, electric power, and natural gas service where available, form the core of public utilities essential for community development. A major consideration in selecting a location for an activity is the accessibility that the location provides to other activities and services (Chapin, 1965). Transportation is essentially a service that enables people, firms, and various other entities to carry on activities at sites selected for these purposes in separated locations. Thoroughfares and transit systems and their terminal facilities exist to make it possible for concentrations of people, firms, and other human institutions to carry on their activities in different locations in space. Although several modes of transportation exist, the discussion in this section will address only road and highway transportation, the principal mode of transportation associated with mining operations and community development.

INFLUENCE OF CULTURAL FACTORS ON COMMUNITY DEVELOPMENT

The cultural factors exert their greatest influence on the siting of community facilities. These factors, which include location, accessibility, size and shape, surrounding land uses, and intensity of use, are critical to the successful development of community facilities. A careful study of these factors should be undertaken to determine the suitability of the site for these high intensity uses. A brief discussion of the influence that these factors exert on the suitability of mined lands for community development is provided below.

Location

The success of a residential development is strongly influenced by its location as well as by the manner in which the major thoroughfare routes approach it and the character of existing and future growth along these lines. Some locational factors to be considered in the selection of a residential site include the following (ULI, 1968).

1. Trends in past local growth should be carefully studied to determine the direction in which high, medium, and low-cost developments have moved. It is very difficult to reverse major directional trends.
2. The access to the site is important. Congested or otherwise undesirable access routes will limit the type of development that can be considered (i.e., high-price vs. low-price developments). It may be possible in some instances to acquire additional land or obtain rights-of-way which will permit an entirely new or improved approach, at least to the general vicinity of the development.
3. Although nearly completed, the national system of interstate highways will not be sufficient to meet the nation's future freeway needs. Accordingly, a continued and accelerated program of express highway construction, particularly in the urban fringe, should follow completion of the interstate system. The network of access and haul roads required by mining operations can help augment an area's transportation system and convert previously unaccessible areas attractive for residential and other uses.

The siting of educational facilities is also strongly influenced by location. In particular, proximity to residential centers is a major determinant of school location. A few other principles of school site location have been recognized (ULI, 1968).

1. Elementary school sites should be located in the interior of a neighborhood for equal access but it should not front on a major thoroughfare because this would expose the children to hazards of heavy traffic and the school to traffic noises.
2. School grounds should be combined with public recreation wherever possible.
3. A junior or senior high school site should be on a major arterial thoroughfare for accessibility and to accommodate the school service area extending beyond the immediate neighborhood.
4. The school site should be laid out for pedestrian access, although street frontage need be on one side of the site only.

Accessibility

Accessibility, closely related to location, is the factor most essential to successful land development, assuming that the land is suitable in terms of topography and geology and that service utilities (water, sewer, gas, and telephone) can be made available. Lack of good access to an otherwise developable site is a common cause of a project's failure. Highway access and transportation facilities to places of employment, the central business district, shopping centers, schools, churches, and recreation places are primary considerations in site selection. Therefore, when considering the development of mined land to residential use, the need to provide the supporting institutional uses must be considered.

Since the automobile is the predominant means of transportation to every daily activity, highway site accessibility becomes very important. Also, the automobile has changed the relationship of transportation between home and place of employment. Accessibility is now measured in terms of minutes in travel time instead of distance in miles. When travel time (by whatever means) to centers of employment is less than 30 minutes, the site location is good. When such travel time is over 30 minutes but not more than 45, the location is fair. A location requiring over 45 minutes travel time is poor, except for a few of the largest cities where an hour is not considered excessive. While proximity to place of employment is not always necessary or desirable, good access in point of time and convenience by both public transportation and private cars will add desirability to any project. Today rapid transit lines, expressways, parkways and controlled-access freeways become indicators to areas for growth and development.

Size and Shape

Another major consideration concerns the total land area as well as the geometric configuration of the site. Each community facility and housing project can impose different size and shape requirements. The dwelling type selected, for example, bears a strong relationship to the total area required. Table 25 provides a comparison of the land area requirements for dwelling types and for neighborhoods of various sizes (Dechiara and Koppelman, 1968). Table 26 shows the relationship among residential area requirements and area requirements for community facilities and utilities for various types of dwellings (Dechiara and Koppelman, 1968).

Space requirements for educational facilities recommended by the Urban Land Institute (1968) are:

Elementary school -- 4 to 6 hectares (10 to 15 acres)
Junior high school -- 8 hectares (20 acres)
Senior high school -- 16 hectares (40 acres)

Surface mining operations in the eastern United States typically range from 4 to 6 hectares (10 to 15 acres) for small operations to 120 to 200 hectares (300 to 500 acres) for large operations. Therefore, a wide range of residential projects is possible, depending on the size of the operation. In addition, if a development project that exceeds the surface area of the mine is projected, adjoining lands may be purchased for that purpose.

TABLE 25. LAND AREA PER FAMILY FOR NEIGHBORHOODS OF VARIOUS SIZES: BASIC ALLOWANCE, IN SQUARE FEET, BY TYPE OF DWELLING AND POPULATION OF NEIGHBORHOOD (Dechiara and Koppelman, 1968)

Dwelling type	1,000 persons (275 families)	2,000 persons (550 families)	3,000 persons (825 families)	4,000 persons (1,100 families)	5,000 persons (1,375 families)
	Square feet per family*				
One- or two-family dwellings					
1-family detached...	9,060	8,600	8,520	8,460	8,440
1-family semi-detached......... or 2 family detached..	6,460	6,000	5,920	5,860	5,840
1-family attached (row)........... or 2-family semi-detached........	4,360	3,900	3,820	3,760	3,740
Multi-family dwellings					
2-story.............	3,425	2,960	2,885	2,825	2,795
3-story.............	2,825	2,360	2,285	2,225	2,195
6-story.............	2,210	1,745	1,670	1,610	1,580
9-story.............	2,095	1,630	1,555	1,495	1,465
13-story............	2,030	1,565	1,490	1,430	1,400

* Calculated with street allowances added.

TABLE 26. LAND AREA PER FAMILY FOR NEIGHBORHOOD OF 5,000 PERSONS (1,375 FAMILIES): ILLUSTRATIVE CALCULATION OF BASIC ALLOWANCES IN SQUARE FEET, BY THE TYPE OF DWELLING (After Dechiara and Koppelman, 1968)

Dwelling type*	Land area in square feet per family and per cent of total									
	Net residential		Streets serving dwellings#		Community facilities		Streets serving com. fac.		Total	
One- or two-family dwellings†										
1-family detached....	6,000	71%	1,800	22%	530	6%	110	1%	8,440	100%
1-family semi-detached.......... or 2-family detached...	4,000	68	1,200	21	530	9	110	2	5,840	100
1-family attached (row)............ or 2-family semi-detached.........	2,400	64	700	19	530	14	110	3	3,740	100
Multi-family dwellings										
2-story.............	1,465	53	600	21	610	22	120	4	2,795	100
3-story.............	985	45	480	21	610	28	120	6	2,195	100
6-story.............	570	36	280	18	610	39	120	7	1,580	100
9-story.............	515	35	220	15	610	42	120	8	1,465	100
13-story.............	450	32	220	15	610	44	120	9	1,400	100

* Dwelling type does not imply that a neighborhood should consist of one dwelling type alone.

† Assumed: average family size 3.6 persons.

Will vary locally with volume of traffic, street widths, parking scheme, etc.

Allowance is approximately 20 percent of area of community facilities.

Surrounding Land Uses

The siting of community facilities is strongly influenced by the type of environment existing or predicted for adjacent properties. A suitable environment is especially important for housing. The suitability of a site for residential development is affected by the following elements (ULI, 1968):

1. Adjacent land use,
2. Traffic streets,
3. Dampness, smoke, and views,
4. Flooding hazards,
5. Fire hazards, and
6. Proximity to airports.

The uses on adjacent property surrounding an available subdivision site may be instrumental in its success or failure. Frontage on a heavily travelled thoroughfare will usually adversely affect single-family residential use. Unless properly located, it should not be assumed as a potential business area. This frontage may be a good location for garden apartment development, however. A compact, closely grouped shopping center is much better than a long line of commercial lots strung out along a highway.

Industrial uses, railroads, cemeteries, poorly subdivided or developed areas and shack developments all lower desirability and values of land for residential purposes. Prevailing winds may carry smoke, fumes, and odors from industrial plants over the area at frequent intervals. This must be checked. Certain types of institutional uses with large open areas will usually be a definite asset, however.

Land within two miles of or under the approach zones to airports has been found to be adversely affected, with desirability for luxury residential use decreased and land values lowered.

The zoning of adjacent tracts whether vacant or built up, and the presence of protective covenants against future adverse uses on these properties should be checked. Also, the effect of any proposed extensions of any adjacent streets or major highways should be evaluated.

An area that forms part of a larger neighborhood or community of similar character and price range to that of the proposed development is always preferable for the small project. Small isolated tracts are seldom good propositions. They are too small to maintain their identity and are likely to be adversely affected by subsequent adjacent development. This latter condition is the case more frequently encountered in surface coal mining operations today and clearly demonstrates the need to develop a more orderly process for the recovery of that mineral resource.

Intensity of Use (Zoning)

The regulation of land subdivision for residential and other uses is widely accepted as a function of municipal and county government in the United States. It has become recognized as a method of insuring sound community growth and safeguarding the interests of the home owner, the land developer, and the local government. Regulations can occur in the following forms: (a) master plan, (b) zoning, (c) subdivision regulations, and (d) building codes. The relationship of zoning to surface mining operations was discussed in Section 3.

INFLUENCE OF NATURAL FACTORS ON COMMUNITY DEVELOPMENT

The natural factors, previously discussed under the groupings of climate, geomorphology, and soils (Sections 5, 6 and 7 respectively), form the basis for an environmental analysis of the suitability of the mine site to support various components of community development. The mine planner must perform two separate analyses of the natural site factors. First, he must evaluate the conditions that exist at the site before the mining operation to set a baseline condition of the site capability. Second, he must evaluate the manner in which these factors will be modified by the mining operation and the potential that exists to modify and possibly improve the existing site conditions.

Geomorphology

The geomorphic factors--topography, slope, exposure, altitude, and drainage--have a strong natural influence on the suitability of a site for community development. A brief summary of the inference of these factors is provided.

Topography and Slope--

Moderately sloping sites are preferable to either steep or very level land. Improvement costs rise sharply on slopes over 10 percent, except where more economical treatment can be applied to hillsides and mountainous areas. (Figures 35 and 36). Heavy site grading improperly done creates settlement and erosion problems. Though the original acreage cost of rough broken land may be less, frequently it will cost more to grade and make usable unless careful site study for cluster arrangements is conducted. In a conventional treatment of hillside land, final improved lot costs will be higher than if more expensive but more level land were purchased. But the advice and services of a geological engineer can offer cost savings by showing how difficult topography can be developed economically.

Relationship between cost of land and cost of lot improvements for steeply sloping sites have been developed. For high-priced properties--where lots are to be developed at no more than three to the acre--broken topography and wooded areas work out very well. But for low-priced houses--where lot improvement costs must be held to a minimum--gently rolling and well-drained land is best. Very flat land presents numerous problems in sewerage and storm drainage that may raise improvement costs to a very high figure.

As previously discussed, the regrading activities of the mining operations offer an excellent opportunity to regrade to the desired contour to enhance or utilize the best suited topography available.

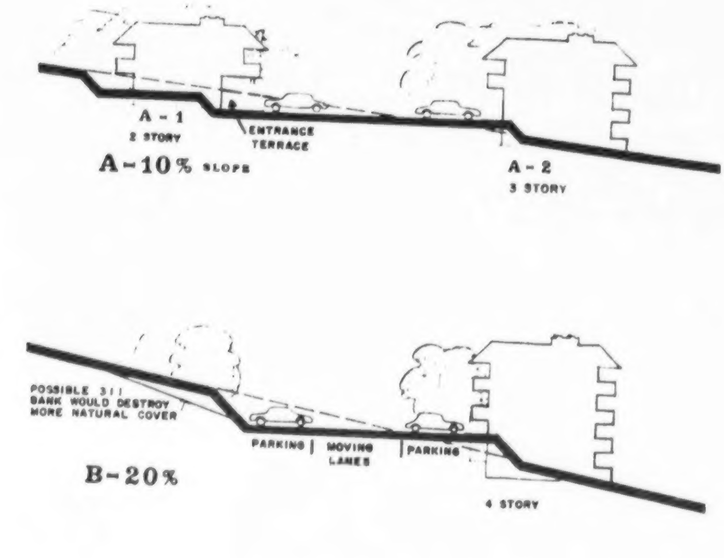
A - 1
2 STORY
ENTRANCE TERRACE
A-10% SLOPE
A - 2
3 STORY
POSSIBLE 3:1 BANK WOULD DESTROY MORE NATURAL COVER
PARKING
MOVING LANES
PARKING
B-20%
4 STORY
1:1 CUT BANKS (SPECIAL TREATMENT FOR STABILIZATION MAY BE NEEDED)
1 1/2 STORY WALK UP
1 1/2 STORY WALK DOWN
C-30%
PARKING ONE SIDE ONLY
POSSIBLE LIGHT WELL
4 STORY
FRONT ENTRANCE BALCONIES
PRIVATE BALCONIES
MOVING LANES
PARKING
D-40%
ELEVATOR - 6 STORY
APARTMENTS

Figure 35. Cross sections showing development techniques (ULI, 1968)

TYPING GUIDE SHEET
BEGIN FIRST LINE OF TEXT HERE
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD: BEGIN SECTIONS HERE

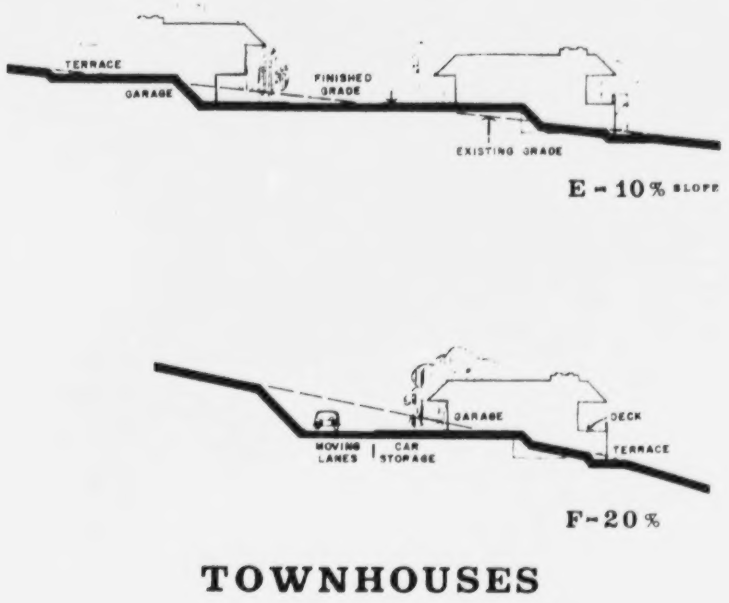
TERRACE
GARAGE
FINISHED GRADE
EXISTING GRADE
E - 10% SLOPE
MOVING LANES
CAR STORAGE
GARAGE
DECK
TERRACE
F-20%
TOWNHOUSES

Figure 36. Siting adapted to grade (ULI, 1968).

BEGIN LAST LINE OF TEXT
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3/8"
PAGE NUMBER
EPA-287 (Cin.)
(4-75)

The shape of the subdivision site should be compact. Irregular boundaries and fragmented properties having utility or railway easements may result in unusable areas and uneconomical street and lot layouts.

The majority of contour mining operations will thus be limited in their postmining potential because of their geometric configuration, a long narrow strip. Mountaintop removal operations and area mining operations, on the other hand, will provide a parcel of well-graded land suitable for many uses.

Drainage--
A site should have good natural surface drainage. A large degree of control over these two factors can be exercised in the reclamation process. Clay, loam, sand, gravel, or other porous material affords good soil drainage and economical construction. Sites with underlying rock close to the surface or high groundwater are relatively expensive to develop.

Since the mining process involves the blasting and shattering of the consolidated subsoil--or overburden--materials, it causes a reconstructed stratigraphic profile that has a very high porosity and thus should provide excellent drainage characteristics. However, the bearing capacity and settling characteristics of the material should be thoroughly analyzed.

Altitude and Exposure--
Although both altitude and exposure should be considered, inasmuch as they closely relate to such climatic factors as temperature and solar radiation, they do not generally act as limiting factors in siting of residential developments. The significance of these factors has been discussed in Section 6.

Soil Factors

The soil factors are closely interrelated with the geomorphic and climatic factors, and together they bear a strong natural influence on the suitability of a site for residential development. The soil properties of greatest interest for residential development include:

1. Flood hazard potential,
2. Wetness,
3. Erodibility,
4. Bearing capacity,
5. Depth to bedrock, and
6. Shrink-swell and slippage.

A brief discussion of these properties as they relate to residential development is provided.

Flood Hazard Potential--
Approximately five percent of the land in the United States is on flood plains. Much of this land is level and seems desirable for home buildings, but the flood potential hazard is often overlooked. In many parts of the country, owners whose homes have been severely damaged by floods were not aware that their homes were built on a flood plain.

A stream may overflow its banks only once in 5 or 10 years, but the chance of eventual damage is high and may increase as more development takes place in the upstream drainage area. Many people don't realize that even a small creek or stream can become a raging, destructive torrent following prolonged or heavy rains. A soil survey map will show the extent of flood-prone areas and indicate the hazard of flooding on soils in such areas. The flood plain limits can then be delineated on a land use map, as illustrated by Figure 37.

Wetness--

A seasonally high water table is a hazard in many areas. The water table may be at safe depths most of the year but rise during the wet season. If the water table rises close to the surface, basements may be flooded, septic tank absorption fields may fail, and plants may be damaged or killed. The county soil survey report will indicate whether in situ soils have a seasonally high water table and will give the depth to the water table. An accurate assessment must be made of the impact that the surface mining operation will have on the groundwater conditions in the postmining stages in order to determine the suitability of the postmining soils with respect to wetness. The companion background report on mine hydrology, Volume 4, discusses this aspect in great detail.

Erodibility--

A correlation generally exists between steep and/or long slopes and erosion caused by rapid rainwater runoff. But even gently sloping areas are susceptible to erosion if grasses and other vegetative cover do not grow well enough to protect the soil.

Bearing Capacity and Shrink-Swell Potential--

If houses are built on certain kinds of clayey soils, the foundations may shift or settle unevenly, and walls, plaster, and foundation may crack severely. Some clayey soils expand as they absorb water and shrink as they dry. This shrinking and swelling can move a house several inches vertically. Unless the foundation is designed for such stress, it is likely to crack.

A special foundation is required for construction on organic soil, such as peat or muck. Even if the house itself remains in place, however, the soil may settle away from the foundation.

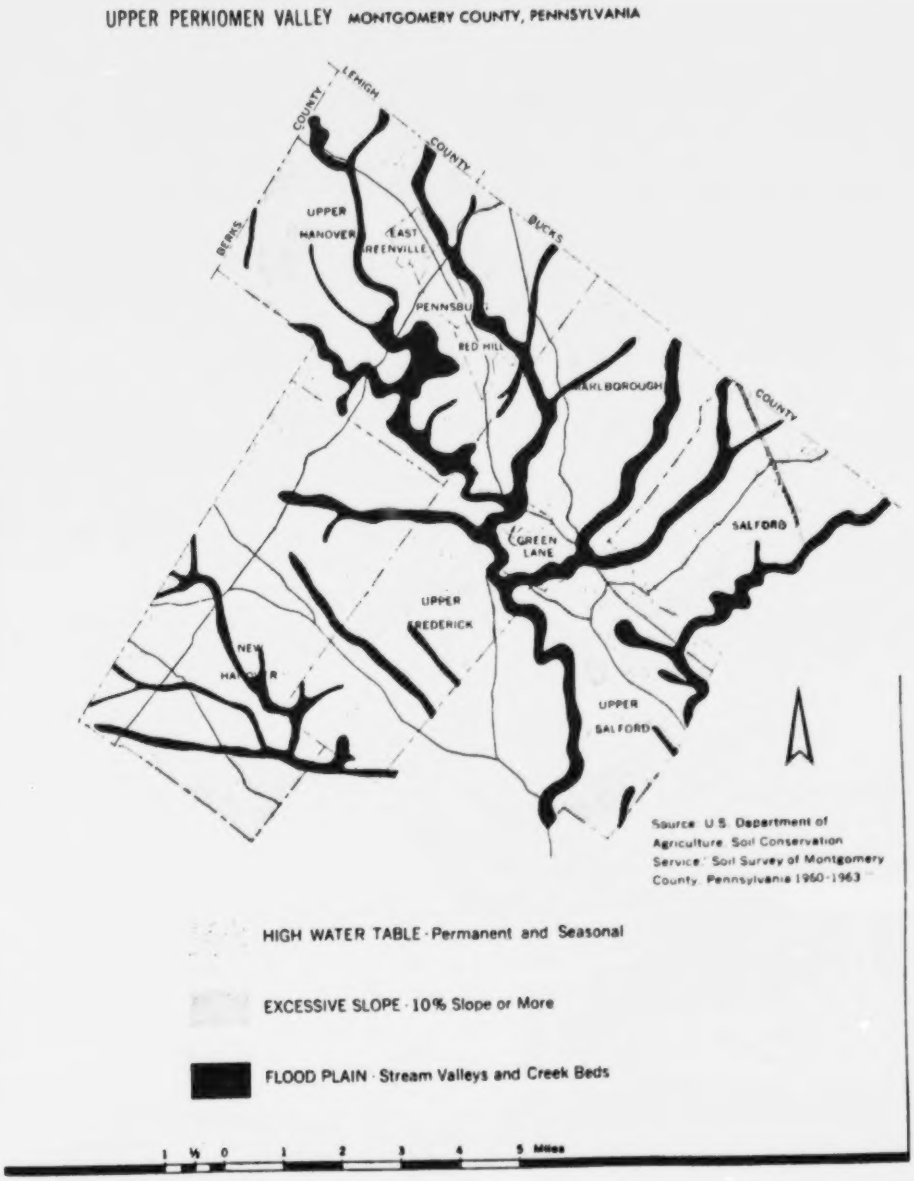
Depth to Bedrock--

Shallow soils over hard rock are undesirable for residential development. Basement construction becomes difficult and costly and landscaping presents troublesome problems since most trees, shrubs, grasses, and flowers grow poorly on most shallow soils.

Use of County Soil Survey Data--

The county soil survey report evaluates the sites in the county and lists the soil limitations for major components of community development.

Table 27 is a sample rating form of community development. For each use, the soils are rated in terms of the degree of limitation--slight, moderate, or severe. The degree of limitation indicates the severity of problems


UPPER PERKIOMEN VALLEY MONTGOMERY COUNTY, PENNSYLVANIA
LEHIGH COUNTY
BERKS COUNTY
BUCKS COUNTY
UPPER HANOVER
EAST GREENVILLE
PENNSBURG
RED HILL
MARLBOROUGH
GREEN LANE
SALFORD
UPPER FREDERICK
NEW HANOVER
UPPER SALFORD
HIGH WATER TABLE · Permanent and Seasonal
EXCESSIVE SLOPE · 10% Slope or More
FLOOD PLAIN · Stream Valleys and Creek Beds
1 ½ 0 1 2 3 4 5 Miles

Source: U.S. Department of Agriculture, Soil Conservation Service, Soil Survey of Montgomery County, Pennsylvania 1960-1963

Figure 37. General soil map of upper Perkiomen Valley, showing soils unsuitable for development (Witmer, 1966).

TABLE 27. SOIL LIMITATIONS FOR COMPONENTS OF COMMUNITY DEVELOPMENT (Centre County, Pennsylvania, 1968)

Soils and mapping symbols		Sewage effluent disposal (on site septic tank)	Sewage lagoons	Homesite location with basements (3 stories or less)	Lawns and landscaping	Streets parking lots (sub-divisions)	Sanitary landfills (trench method)	Cemeteries (community)
Albrights silt loam	59B2	Severe--Seasonal high water table, moderately slow permeability	Moderate--Slope	Moderate--Seasonal high water table	Slight	Moderate--Slope, seasonal high water table	Moderate--Seasonal high water table	Moderate--Seasonal high water table
	59C2	Severe--Seasonal high water table, moderately slow permeability	Severe--Slope	Moderate--Seasonal high water table	Moderate--Slope	Severe--Slope	Moderate--Slope, seasonal high water table	Moderate--Slope, seasonal high water table
Albrights very stony silt loam	60AB	Severe--Seasonal high water table, slow permeability	Moderate--Slope	Moderate--Seasonal high water table	Moderate--Stony	Moderate--Seasonal high water table, slope, stoniness	Moderate--Seasonal high water table	Severe--Stoniness

(continued)

TABLE 27. (continued)

Soils and mapping symbols	Sewage effluent disposal (on site septic tank)	Sewage lagoons	Homesite location with basements (3 stories or less)	Lawns and landscaping	Streets parking lots (sub-divisions)	Sanitary landfills (trench method)	Cemeteries (community)
Albrights very stony silt loam 60CD	Severe--Seasonal high water table, slope	Severe--Slope	Severe--Slope	Severe--Slope	Severe--Slope	Severe--Slope	Severe--Slope
Allegheny silt loam 26B2	Slight--Hazard of ground water contamination	Severe--Permeable substratum	Slight	Slight	Moderate--Slope	Slight--Hazard of ground water contamination	Slight
Amaranth silt loam 36B2	Severe--Seasonal high water table, slow permeability	Moderate--Slope	Moderate--Seasonal high water table	Slight	Moderate--Seasonal high water table, slope	Severe--Slow permeability	Severe--Slow permeability

expected to be encountered for the specified use. Major limiting factors are also listed when the soil has a moderate or severe rating. The three degrees of limitation are defined as follows:

1. Slight--These soils have few known limitations for the use indicated.
2. Moderate--These soils have one or more properties that limit their use. Correcting these factors will increase the installation and maintenance costs.
3. Severe--These soils have one or more properties that seriously limit their use. Using soils with a severe limitation will increase the probability of failure and add to the cost of installation and maintenance.

The decision as to whether or not a soil will be used for a specific purpose, regardless of the limitation, is beyond the scope of this information. At a price, almost any limitation can be overcome. The information contained in Table 27 will be valuable in planning more detailed field surveys to determine the in-place condition of the soil at the site.

Table 27 rates the soils in the county for the following seven components of community development:

1. Sewage effluent disposal,
2. Sewage lagoons,
3. Homesite location with basements,
4. Lawns and landscaping,
5. Streets and parking lots,
6. Sanitary landfills, and
7. Cemeteries.

Climatic Factors

The climatic factors, including temperature, humidity, precipitation, solar radiation, and wind, are strongly influenced by the geomorphology of the site and in turn have a strong impact on the site. Although the climatic factors do not generally serve as constraints to the siting of residential areas, these factors must be considered in the design of a residential development. The design process commonly consists of identifying the climatic factors and adjusting the design of the development to provide acceptable levels of comfort.

OTHER FACTORS

Land Costs

Ordinarily the proposed selling or rental price of the dwelling units, based on careful analysis of the market, should determine the price that can be paid for the land. Typically, 18 to 25 percent of the selling price of the dwelling unit is allocated to land costs. However, in surface mining operations the land costs may be associated with the purchase of the mineral rights and, therefore, would not represent a major consideration or obstacle.

A number of opportunities are presented to the mine operator. If market conditions indicate that the site is suitable for development, he can regrade the site to suit the potential land developer and thus recover a substantial portion of his land acquisiton and reclamation costs. Subdivision lot development cost items can be listed as follows (ULI, 1968):

1. Grading and clearing,
2. Paving: streets, curbs, gutters, sidewalks,
3. Storm drainage,
4. Sewer and water,
5. Sodding, landscaping,
6. Financing,
7. Engineering,
8. Bonds and permits,
9. Sewer and water taps, and
10. Costs to bring utilities to site.

A number of these cost items can be included as part of the reclamation process, and thus the mine operator can add the value of these improvements to the selling price or value of his land after mining.

Utility Services

No factors in site selection are more important than the availability of water, sanitary and storm sewers, electricity, gas, and public transportation. Lines for the utility services should be at or near the site when it is a normal subdivision. They should also be of adequate capacity to carry the increased load of the new development and future development of the surrounding tributary area.

The mining process can provide some help in several of these areas. The detailed hydrologic investigations now required to monitor the impact of the mining operations on the hydrologic system should prove valuable in assessing the potential of the site for development of a groundwater supply. Further, the elaborate soil and subsoil analyses should help to identify the suitability of the site for septic tank disposal of sewage.

The current trend towards the use of larger stripping equipment is accompanied by a trend towards the use of electrical power as well. This often results in the installation of an electrical substation at the site that should prove valuable for land development purposes.

Highways--

The importance of good transportation--and highways in particular--has been stressed several times in this report. The relationship between location and accessibility and the presence of a good road system has been introduced. The coal haul roads that are necessary for transporting the coal to the preparation plant have the potential to form the nucleus for a suitable road network in the postmining stages. Recognizing this potential, some basic materials related to highway classification, planning, and use are presented to stimulate and guide the mine planner in implementing this concept.

Highway systems are grouped into a number of different classifications. In the most basic classification system for design work, highways, and streets are grouped into (1) interstate, primary (excluding interstate), secondary, and tertiary roads in rural areas, and (2) expressway, arterial, collector, and local roads in urban areas. These classifications usually carry with them a set of suggested minimum design standards which are in keeping with the importance of the system and are governed by the specific transportation services the system is to perform. Table 28 provides a general summary of highway and street standards (Dechiara and Koppleman, 1968).

Four basic puroses of urban street systems, as illustrated in Figure 38, have been suggested (Dechiara and Koppelman, 1968).

1. Expressway system (including freeways and parkways) provides for expeditious movement of large volumes of through traffic between areas and across the city and is not intended to provide land-access service.
2. Major arterial system provides for through traffic movement between areas and across the city, and direct access to abutting property.
3. Collector or street system provides for traffic movement between major arterials and local streets and direct access to abutting property.
4. Local street system provides for direct access to abutting land and for local traffic movements.

These basic purposes of accommodating through traffice as well as land access within city street systems are similar to those purposes of rural interstate, primary, secondary, and tertiary highways, respectively. However, regional as well as national highway transportation requirements must be met by rural highway classifications.

The principles and elements of geometric design for both urban and rural facilities are generally the same. However, to meet urban and rural demands, design details are often varied because speeds, traffic composition, lengths and purposes of trips, etc., are not the same.

TABLE 28. GENERAL HIGHWAY AND STREET STANDARDS (Dechiara and Koppelman, 1968)

Type of facility	Function and design features	Spacing	Widths	
			R.O.W.	Pavement
Freeways	Provide regional and metropolitan continuity and unity. Limited access; no grade crossings; no traffic stops.	Variable; related to regional pattern of population and industrial centers.	200-300'	Varies; 12' per lane; 8-10' shoulders both sides of each roadway; 8-60' median strip.
Expressways	Provide metropolitan and city continuity and unity. Limited access; some channelized grade crossings and signals at major intersections. Parking prohibited.	Variable; generally radial or circumferential.	200-250'	Varies 12' per lane; 8-10' shoulders; 8-30' median strip.
Major roads (major arterials)	Provide unity throughout contiguous urban area. Usually form boundaries for neighborhoods. Minor access control; channelized intersections; parking generally prohibited.	1 1/2 to 2 miles	120-150'	84' maximum for 4 lanes, parking and median strip.
Secondary roads (minor arterials)	Main feeder streets. Signals where needed; stop signs on side streets. Occasionally form boundaries for neighborhoods.	3/4 to 1 mile	80'	60'
Collector streets	Main interior streets. Stop signs on side streets.	1/4 to 1/2 mile	64'	44' (2-12' traffic lanes; 2-10' parking lanes)
Local streets	Local service streets. Non-conducive to through traffic.	at blocks	50'	36' where street parking is permitted.
Cul-de-sac	Street open at only one end, with provision for a turn-around at the other.	only wherever practical	50' (90')	30-36' (75' turn-dia. around)

(continued)

TABLE 28. (continued)

Type of facility	Desirable Maximum Grades	Speed	Other features
Freeways	3%	55 mph	Depressed, at grade, or elevated. Preferably depressed, through urban areas. Require intensive landscaping, service roads, or adequate rear lot building set-back lines (75') where service roads are not provided.
Expressways	4%	50 mph	Generally at grade. Requires landscaping and service roads or adequate rear lot building set-back lines (75') where service roads are not provided.
Major roads (major arterials)	4%	35-45 mph	Require 5' wide detached sidewalks in urban areas, planting strips (5-10' wide or more) and adequate building set-back lines (30') for buildings fronting on street; 60' for buildings backing on street.
Secondary roads (minor arterials)	5%	35-40 mph	Require 5' wide detached sidewalks, planting strips between sidewalks and curb 5' to 10' or more, and adequate building set-back lines (30').
Collector streets	5%	30 mph	Require at least 4' wide detached sidewalks; vertical curbs; planting strips are desirable; building set-back lines 30' from right of way.
Local streets	6%	25 mph	Sidewalks at least 4' in width for densities greater than 1 d.u./acre, and curbs and gutters.
Cul-de-sac	5%		Should not have a length greater than 500 feet.

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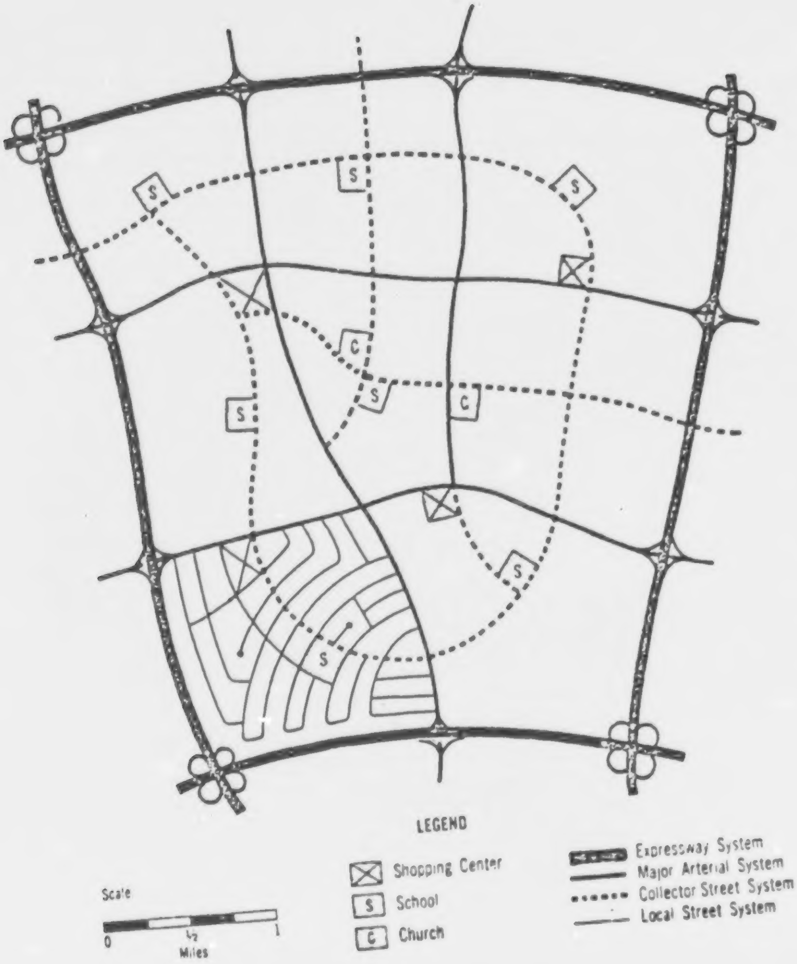
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Figure 38. Illustration of basic purpose of urban street system (Dechiara and Koppelman, 1968).

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APPENDIX A. USDA DESCRIPTION OF SOIL HORIZONS (USDA, 1951)

THE A_o AND A_{oo} HORIZONS

The A_o and A_{oo} horizons lie above the A_1 horizon of unplowed soils. They are not strictly parts of the A horizon or of the solum as herein defined, although, from some points of view, they might be so regarded.[1] The exclusion of these horizons from the solum in no way suggests that they are unimportant or that careful recognition is not essential to a useful description of many soils. Many important soil-forming processes owe their origin in part to materials produced in these layers. Although these horizons have typical thicknesses and characteristics for any one soil type under the normal undisturbed vegetation, their actual thicknesses vary widely because of fire and other common disturbances. These horizons are especially well developed in Podzols and are found on most unburned forested soils, although they are exceedingly thin on some. Thin but important A_o or A_{oo} horizons are occasionally found also on soils developed under grasses and desert shrubs.

A_{oo} horizon is a surface horizon, below A_o if present and above A_1; it consists of partly decomposed or matted plant remains.

The letters L, F, H, or others to indicate the character of the organic material, may be used in the description of A_{oo}, A_o, and A_1 horizons in addition to the designations suggested, but not in place of them (Heiberg and Chandler, 1941; Lunt, 1948). Subdivisions of A_o horizons are made as they are for any others.

The A_o and A_{oo} horizons are measured upward from the top of the A_1, if present, or otherwise from the upper mineral soil horizon. It is important to observe this convention. The thickness of the A_o and A_{oo} horizons varies so greatly with fire that the surface of the A_1, or upper mineral soil, must be used as a general reference point rather than the upper surface of the A_{oo}.

THE A HORIZON

The A horizon is a master horizon consisting of (1) one or more surface mineral horizons of maximum organic accumulation; (2) surface or subsurface horizons that are lighter in color than the underlying horizon and that have lost clay minerals, iron, and aluminum with resultant concentration of the more resistant minerals; or (3) horizons that belong to both of these categories.

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[1] Some letter other than A would be chosen by the authors for these layers if the use of A_o and A_{oo} were not so well established.

The A horizon, and especially the A_1, is the horizon of maximum biological activity and is subject to the most direct influences of climate, plants, animals, and other forces in the environment. In a sense, the A protects the rest of the soil; and in it many of the most important soil-building forces have their origin.

When the A horizon is used without subscript numbers, it refers collectively to all the subhorizons in it, excluding A_o and A_{oo}. The subhorizons are named and described in the following paragraphs.

A_1 horizon is a surface mineral soil horizon with a relatively high content of organic matter mixed with mineral matter, usually dark in color. It may or may not be a horizon of eluviation. In nearly all soils it is the horizon of maximum biological activity and is subject to the greatest changes in temperature and moisture content. It is very thick in Chernozems and exceedingly thin in many Podzols. In some Podzols, groundwater Podzols, groundwater Laterites, and other soils, it is destroyed by repeated fires. Measurements of all horizons are referred to the top of the A_1, if present.

A_2 horizon is a surface or subsurface horizon, usually lighter in color than the underlying horizon, that has lost clay minerals, iron, or aluminum (or all three) with the resultant concentration of the more resistant minerals. It is an horizon of eluviation--of leaching of materials in solution and suspension.[2] Much of the dissolved and dispersed material, including clay, moves completely out of the whole soil, not simply into the B horizon. The A_2 is the principal gray or light-colored leached layer in Podzols (bleicherde), solodized-Solonetz, Planosols, and Podzolic soils generally.

A_3 horizon is an horizon transitional to the B but more like the A than the B. (If a transitional horizon between A and B is not clearly divided, and especially where it is thin, it may be designated AB.)

A_p horizon is a plowed or otherwise mixed surface horizon including more than the original A_1 horizon. The subscript letter p indicates disturbance, usually by cultivation but occasionally by pasturing. Where the plow layer is entirely within the A_1 horizon, it is designated as A_{1p}.

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[2] A horizon within B or C resulting, for example, from leaching by water moving laterally through a gleyed layer, may fall within this concept of an A_2 horizon.

THE B HORIZON

The B horizon is a master horizon of altered material characterized by (1) an accumulation of clay, iron, or aluminum, with accessory organic material[3]; (2) more or less blocky or prismatic structure, together with other characteristics, such as stronger colors (unlike those of the A or the underlying horizons of nearly unchanged material); or (3) characteristics of both these categories. Commonly, the lower limit of the B horizon corresponds with the lower limit of the solum.

Actually the accumulation of clay and the development of blocky or prismatic structure are covariant in many soils but not in all of them. The relatively small accumulations of total clay in the B horizons of typical Chernozem and Chestnut soils, and in some Podzols, are not primarily responsible for their designation as B horizons.

Commonly, the B is called an illuvial horizon, in the sense that colloidal material carried in suspension from overlying horizons has lodged in it. The clay in B horizons may also originate from differences of residual clay formation in place or by recombination of soluble materials brought into it in true solution. Texture differences between A and B horizons may also arise partly from differential destruction of clay, as in red-yellow Podzolic soils for example, as well as from illuviation and residual formation in place. When B horizon is used without subscript number or letter, it refers collectively to all subhorizons in it. These subhorizons are named and defined in the following section.

B_1 horizon is transitional to the A above but more like the B than A.

B_2 horizon is the subhorizon of (1) maximum development of silicate clay minerals or of iron and organic material; (2) maximum development of blocky or prismatic structure; or (3) may have characteristics of both. In B_2 horizons having both these features (but separated) the horizons need to be subdivided into B_{21} and B_{22}, as appropriate.

B_3 horizon is transitional to the C horizon but more like the B than C.

THE C HORIZON

The C horizon[4] is a layer of unconsolidated material, relatively little affected by the influence of organisms and presumed to be similar in chemical, physical, and mineralogical composition to the material from which at least a portion of the overlying solum has developed. Any slight alteration of the upper part of the C, such as reduction of calcium carbonate content in glacial till, unaccompanied by other changes, is designated as C_1.

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[3] Organic material is the chief added constitutent in the B horizon of some groundwater Podzols and in "human" Podzols.

[4] Although commonly used and understood, the C is not strictly a soil horizon as herein defined, partly because it is little modified by biological processes in soil formation, and partly because it often has an undetermined lower limit.

THE D LAYER

The D layer is any stratum underlying the C, or the B if no C is present, which is unlike C, or unlike the material from which the solum has been formed. The designation D_r is for consolidated parent rock like that from which the C has developed or like that from which the parent material of the solum has developed if no C is present.

OTHER HORIZONS

Besides the common horizons already defined, there are others that occur importantly but less regularly.

G horizon is a layer of intense reduction, characterized by the presence of ferrous iron and neutral gray colors[5] that commonly change to brown upon exposure to the air. It is a characteristic horizon in soils developed wholly or partly by gleying. This process involves saturation of the soil with water for long periods in the presence of organic matter. One may speak appropriately of a gley (glā) soil but hardly so of a gley horizon since the genesis of the whole profile is involved. Besides the G, other horizons may be somewhat gleyed, indicated by the subscript g. Occasionally it may be necessary to differentiate in the description between C and G may be indicated as BG and DG if more strongly gleyed than indicated by B_g and C_g.

The G horizon is usually included as part of the solum, along with A and B, but those G horizons occurring within the C or beneath it are not.

C_{ca} horizon[6] is a layer of accumulated calcium carbonate below the solum and within the C. Such horizons are characteristic of most Chernozemic and other soils of subhumid and semiarid regions. The C_{ca} horizon is not always clearly expressed in Chernozems and sometimes can be detected only by laboratory methods. It is found in some prairie soils and in some Podzolic soils, especially those developed from highly calcareous unconsolidated material. This layer may be thin or thick and soft or very hard. Generally, the thickness and hardness increase from cool to warm climates. In cool and cool-temperate regions, the hard layers are found mostly in gravel. In warm semiarid regions this layer becomes so thick that it can no longer be regarded strictly as a soil horizon. Although the explanation of its genesis is not wholly settled, broad geological processes as well as those included under soil formation have undoubtedly contributed. The term caliche is applied to C_{ca} horizons, especially to the thick ones in the warm countries of the Western Hemisphere. For the hardened ones, croûte calcaire is an alternative term for hardened caliche.

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[5] Some G horizons have olive colors--a few too nearly green for the standard color chart.

[6] The use of ca as an abbreviation of calcium carbonate is preferred as a subscript to Ca, the chemical symbol, partly to have all letter subscripts uncapitalized.

Formerly C_c was used for what is now designated as C_{ca}. The subscript ca can also be used for accumulations of calcium carbonate in other horizons or layers.

C_{cs} horizon is a layer of accumulated calcium sulfate within the C. Such horizons commonly occur beneath the C_{ca} horizons of Chernozemic soils. The subscript cs may also be used for accumulations of calcium sulfate in other horizons or layers.

POPULAR TERMS FOR SOIL LAYERS

Several popular terms have long been used to refer to certain soil horizons or groups of horizons--terms that are exceedingly difficult to define precisely. They are very old and have been used by laymen in widely different senses.

Topsoil is a general term that is used in at least four senses: (1) for the surface plowed layer (A_p) and thus as a synonym for surface soil; (2) for the original or present A_1 horizon, and thus exceedingly variable in depth among different soils; (3) for the original or present A horizon; and (4) for presumed fertile soil or soil material, usually rich in organic matter, used to top-dress road banks, parks, gardens, and lawns.

No way seems clear to settle on a specific definition that would make the term even reasonably clear in soil descriptions. It should be avoided except as a top-dress material.

Surface soil refers to the soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The depth varies among different soil regions. If the term is used without qualification, reference is made to a former condition, the term needs to be modified to original surface soil, as in the statement, "50 percent of original surface soil has been lost by sheet erosion."

Subsurface soil refers to that part of the A horizon below the surface soil. In soils of weak profile development subsurface soil can be defined only in terms of arbitrary depths.

Subsoil refers to the B horizon of soils with distinct profiles. In soils with weak profile development, subsoil can be defined as the soil below the surface soil in which roots normally grow or in terms of arbitrary depths. It is a poor term inherited from the days when "soil" was conceived only as the plowed soil; hence that under it was "subsoil."

Substratum is any layer beneath the solum, either conforming (C) or unconforming (D).